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BULLETIN

OF THE

American Museum of Natural History.

Vol. XXIII, 1907.

EDITOR, J. A. ALLEN.

NEW YORK:
Published by order of the Trustees.
1907.

FOR SALE AT THE MUSEUM.

199463

(*Continued from 3rd page of cover.*)

ETHNOGRAPHICAL ALBUM.

Jesup North Pacific Expedition.

Ethnographical Album of the North Pacific Coasts of America and Asia. Part I, pp. 1–5, pll. 1–28. August, 1900. Sold by subscription, price, $6.00.

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"	XXI, 1905	"	5.00
"	XXII, 1906	"	6.00
"	XXIII, 1907	"	9.00

ANTHROPOLOGICAL PAPERS.

Vol. I, Nos. 1–3, 1907.

AMERICAN MUSEUM JOURNAL.

The 'Journal' is a popular record of the progress of the American Museum of Natural History, issued monthly, from October to May inclusive. Price, $1.00 a year. Volumes I–VI, 1900–1906.

For sale at the Museum.

* Published by E. J. Brill. Leiden, Holland. Not on sale at the Museum American Agent, G. E. Stechert, 129 West 20th Street, New York City.

Printed by Edward W. Wheeler, Cambridge, Mass.

BULLETIN

OF THE

American Museum of Natural History.

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The edition of authors' separates is 200, of which about 70 are mailed on the date of issue, and the others placed on sale in the Library.

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" III, " 16, 1907.
" IV " 25, 1907.
" V, " 25, 1907.
" VI, " 25, 1907.
" VII, " 25, 1907.
" VIII, " 25, 1907.
" IX, March 14, 1907.
" X, " 27, 1907.
" XI, " 30, 1907.
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" XIII, " 30, 1907.
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" XV, " 30, 1907.
" XVI, April 15, 1907.
" XVII, " 22, 1907.
" XVIII, July 26, 1907.
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" XX, " 12, 1907.
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" XXII, " 12, 1907.
" XXIII, Aug. 20, 1907.
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" XXIX, Aug. 26, 1907.
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ERRATA.

Page 287, line 25, for PODICIPETIDÆ read PODICIPITIDÆ.
" 294, " 18, for autonymic read tautonymic.
" 295, " 32, for 1840 read 1855.
" 297, " 4 from bottom, for Gray (1840) and by elimination read the founder.
" 305, " 8, " " for Sharp read Sharpe.
" 306, " 9, " " for 189 read 187.
" 308, " 10, for *fisheri* read *fischeri*.
" 312, " 2, from bottom, for 1840 read 1855.
" 317, bottom line, for *Anucylocheilus* read *Ancylocheilus*.
" 323, line 13, for **Dendragopus** read **Dendragapus**.
" " " 14, " *Dendragopus* read *Dendragapus*.
" 327, " 21, " *Zenaidura* read *Zenaida*.
" 334, " 24, " Latham read Pennant.
" 237, " 7, " *Pyrhula* read *Pyrhura*; also on p. 238, lines 9 and 11 from bottom.
" 348, " 7 from bottom, for 1852 read 1859.
" 350, " 5, for CABANIS read HARTLAUB.
" 367, " 18, " *Xipholema* read *Xipholena*.
" 371, " 8 from bottom for *Motacilla* read *Muscicapa*.
" 373, " 22, for 1848, i, 98, read 1847, i, 323.
" 375, " 13, " 17 read 77.
" " dele line 14 and insert: 2 congeneric species. Type, *C. stellaris* Licht., as designated by Gray in 1855.
" 440, " 23 and 32 for Tomochic read Temochic.
" 442, lines 13 and 14, for limestone schists, read limestone and schists.

BULLETIN

OF THE

AMERICAN MUSEUM OF NATURAL HISTORY.

VOLUME XXIII, 1907.

59. 57, 96: 11.51

Article I. — THE POLYMORPHISM OF ANTS, WITH AN ACCOUNT OF SOME SINGULAR ABNORMALITIES DUE TO PARASITISM.

BY WILLIAM MORTON WHEELER.

PLATES I–VI.

The study of sex determination among organisms — a subject obviously included under the greater problem of the origin of variation, since sexual dimorphism is the most striking and constant form of intraspecific variability both in animals and plants — and the related but much more restricted problem of polymorphism, have of late attracted the attention of many biologists. A perusal of some of the literature bearing on these subjects, however, has convinced me that the simplicity of the questions involved may have been overestimated. That this is especially true of polymorphism as manifested in the social insects, will, I believe, be evident from a consideration of the facts recorded in the following paper. At any rate, it will not be a difficult task to show that we are still very much in the dark concerning the fundamental causes of the differentiation of one sex into several distinct phases, and, while it may be urged that the problem of polymorphism as it is presented by the social insects, may be more complicated than that of sex, on purely *a priori* grounds the opposite view would seem to be the more probable, for polymorphism is undoubtedly not only a more restricted phenomenon but one of much more recent phylogenetic and ontogenetic development, and hence presumably dependent on conditions both more specialized and more amenable to observation and experimentation. While the observations recorded in this article suggest both the need of experiment and some of the points at which the problem is open to this method of investigation,

they indicate with equal force that the causes of polymorphism may be so recondite as to give little encouragement to the crude physiological methods at present available. In other words, much water will have to flow through the biological mill before we possess sufficient knowledge of the physiological chemistry of such small organisms as the insects, to enable us to determine the exact nature of the subtle influences that decide whether an ant or bee shall become a queen or a worker.

The following observations relate to some of the unusual or pathological individuals occasionally found in ant colonies, and referable, with more or less probability, to trophic disturbances induced by specific parasites. The inferences from these cases have a value approaching those derived from experiment, since the phenomena make their appearance only under very definite circumstances.

PART I. OBSERVATIONS.

1. The Parasitism of Orasema and other Chalcididæ on ants.

A. Orasema viridis Ashmead.

This beautiful Chalcidid is abundant in Texas in the nests of *Pheidole kingi* André subsp. *instabilis* Emery, but only from May to September. For this reason I failed to notice it till May 25, 1903, about six weeks before I moved from Austin to New York, although during my four years' residence in Texas I had examined hundreds of *instabilis* nests during the autumn, winter, and early spring months. I was so much impressed with the peculiar behavior of the *Orasema* and the ants that I devoted to the subject every available moment of the short remainder of my sojourn in Texas, but the necessary preparations for my departure, the intense heat, which sets in during the month of May, and a peculiar misunderstanding of the conditions under which the *Orasema* develops, seriously interfered with the progress of my work. It was only after I had left Texas that the study of preserved material led me to what I believe to be a correct interpretation of the life history of the insect.

Before describing the *Orasema* and its development it will be necessary to say something about the host. *Ph. instabilis* is a common ant in central Texas and certain parts of Mexico, at least as far south as the State of Morelos, where I have taken it near Cuernavaca. It forms populous colonies which prefer to nest under stones in sunny places. In central Texas

it is often found in bottom lands and waste places where the soil is rich and supports an open growth of grasses and especially of Crotons (*Croton texensis* and *C. monanthogynus*). It is a harvesting species and stores the flat chambers of its nests with innumerable seeds collected from all the plants in the neighborhood. Like other harvesting ants, however, it does not confine itself to a vegetable diet, but eagerly seizes on any insect food that may fall in its way.

In common with other members of the great genus *Pheidole*, *instabilis* presents four phases known as the soldier, worker, female and male respectively. The soldier is 4–4.5 mm. long. The shape and extraordinary proportions of its head are shown in Plate I, Fig. 1, and Plate V, Fig. 63 *o*. Its gaster is black and shining, the mandibles and clypeus are dark brown, the remainder of the head, thorax and appendages reddish brown.

The head is subopaque and elaborately sculptured as shown in the figure. The worker (Pl. I, Fig. 7, and Pl. V, Fig. 63 *c*) is only 1.5–1.8 mm. long. It is shining throughout, and of a dark brown or black color with yellowish appendages. The female (Pl. I, Fig. 8 and Pl. V, Fig. 63 *a*), which measures 5.5–6 mm., is dull black, with the legs, antennæ, mandibles and anterior half of the head yellow. The wings (removed in the specimen figured) are yellowish hyaline with pale veins. The male (Pl. I, Fig. 9 and Pl. V, Fig. 63 *e*) is a much smaller and more graceful insect than the female, measuring only 4–4.3 mm. Its head and gaster are black, its thorax and appendages sordid yellow, the former with pale sutures. Its wings resemble those of the female.

While *instabilis* agrees with its congeners in having the four phases just described, it differs from all except a small group of North American species of *Pheidole* in presenting in every well-developed colony a series of individuals intermediate in size, structure, and sculpture between the soldier (Pl. I, Fig. 1) and the worker (Pl. I, Fig. 7). This series, which is very complete in large colonies, is represented in Plate I by a few selected individuals (Pl. I, Figs. 2–5 and Pl. V, 63 *r*). The occurrence of such intermediate forms, though well-known in some other genera of ants, like *Solenopsis* and *Camponotus*, is so unusual in the genus *Pheidole* as to call for the special explanation which I shall attempt to give in the sequel. It is also an interesting fact that the organs are not always reduced in size in strict correlative proportions as we descend the series of intermediate individuals from the soldier to the worker. As shown in Plate I, Figs. 5 and 6, for example, the antennal scape may be of the same length in two individuals which differ considerably in the size of the head. Or, again, as shown in figure 4, the scape may be longer in one individual than in others with larger (Pl. I, Fig. 3), or smaller heads (Pl. I, Figs. 5 and 6).

The acme of the colonial activities of *Ph. instabilis* is attained during the latter part of May and the first weeks of June. Then the nest is full of eggs, larvæ, pupæ, and callows of all the castes and presents a bewildering appearance, owing to the fact that the brood is not assorted according to ages, as in many ants, but lies jumbled together in the different chambers and galleries. The functions of the workers and soldiers are clearly distinct. The former are far and away the more numerous, and notwithstanding their diminutive size, may be said to manage the affairs of the colony. They collect the seeds and dead insects and drag them to the nest. They excavate the galleries, feed the brood and carry even the huge female larvæ and pupæ from chamber to chamber and assist the callows in escaping from their pupal envelopes. The soldiers act as carvers, or trenchers of the tough insects and hard seeds brought in by the workers. Their powerful mandibles admirably fit them for this office and for guarding the nest. They are often seen to form a stationary cordon about the brood and the callows in the chambers. They are never seen to eat the seeds or insects which they cut up for the other members of the colony but are fed on liquid food regurgitated by the workers. They are very stolid and inactive, very rarely leave the nest and never assist in carrying the larvæ and pupæ about. Their heads are so large in proportion to their bodies that, when dropped on their backs on a smooth surface like that of glass or polished wood, they are often unable to right themselves and may die standing on their heads. The intermediates are much more active and may be seen to leave the nest, collect food, carry larvæ and, in short, perform all the duties of the workers which they approach in their smaller size and smoother sculpture.

The larvæ of all the castes are provided with several pairs of flexuous, anchor-tipped dorsal hairs, by means of which they may be temporarily fixed to the earthern walls of the chambers or to the rough surfaces of the stone covering the nest. While in this position they are fed by the workers with bits of crushed seeds or insect fragments in the same way as the larvæ of the Ponerine ants. At least the younger larvæ of the males and females, however, appear to be fed largely, if not exclusively, with regurgitated liquid food.

Ph. instabilis is very common at Austin in the bottom and along the banks of a small limestone cañon, known as Shoal Creek. There, during May and June, 1903, I found a great number of colonies. Several of them were confined in artificial nests of the Fielde pattern and one was kept under observation till the latter part of September. I also preserved whole colonies in alcohol after killing them in water heated to 80° C.

Fully half of the colonies examined were found to contain the peculiar parasites which Dr. W. H. Ashmead has kindly identified for me as *Orasema*

viridis Ashm., a Chalcidid fly originally described from specimens collected at large by Mr. E. A. Schwarz near San Diego, Texas.

The genus *Orasema,* which belongs to the subfamily Eucharinæ, was originally established by Cameron on *O. stramineipes* from Panama, in the 'Biologia Centrali-Americana'.[1] According to Ashmead,[2] this genus is characterized by the possession of 10-jointed antennæ in both sexes, and in having the right mandible two-toothed, the left with a single tooth, and both mandibles acute and falcate at their tips. The genus appears to be largely restricted to tropical and subtropical America but extends somewhat further north in the western than in the eastern portion of the United States.

The female *O. viridis* (Pl. I, Fig. 10, and Pl. V, 63 *m*) measures 2.5–3 mm. and is deep metallic green with the clypeus and thoracic dorsum more golden and the gaster blue or violet. The head, thorax and petiole are uniformly and densely punctate, the gaster very smooth and shining. The legs are honey-yellow, excepting the middle portions of the femora, which are metallic green, and the terminal tarsal joints, which are black. The antennæ are black, with the basal joints yellow, as are also the mandibles, tongue, and palpi. The wings are very clear and iridescent. The epinotum and scutellum together form a rounded cone through which the thorax reaches a greater vertical diameter than it does elsewhere. The male (Pl. I, Fig. 11, and Pl. V, Fig. 63 *n*) is distinctly smaller than the female (2.3–2.5 mm.) and differs in having a much longer petiole, a much shorter and smaller gaster, and longer and thicker antennæ, with the basal joints black instead of yellow.

On opening a large *instabilis* nest a dozen or more of these superb insects may be seen lying on their sides or creeping about among the ant-brood (Pl. V, Fig. 64). It is also easy to recognize their pupæ, white when young or nearly ready to hatch, of a dull blue-green color when mature, scattered among the larvæ and pupæ of their hosts. Such nests present a splendid appearance, reminding one of a jewel casket in which the sapphires and emeralds are represented by the *Orasema,* the pearls by the larvæ and pupæ, the opals by the iridescent wings of the parasites and of the male and female ants, the garnets and bits of jet by the glistening black and red seeds and the red heads and black bodies of the soldiers.

As soon as the nest is disturbed, the workers seize the *Orasemæ* and their pupæ and, even at the risk of neglecting their own brood and callows, carry them bodily to a place of safety. In artificial nests this great fondness for the *Orasema* may be witnessed at one's leisure. The adult parasites are not only carried about and continually licked and fondled, but are also fed

[1] Vol. I, 1883–1900, pp. 104, 105, pl v, fig. 20, pl. vi, fig. 18.

[2] Classification of the Chalcid Flies or the superfamily Chalcidoidea. Mem. Carnegie Museum, No. 4, 1904, pp. ix, 225–551, pll. xxxi-xxxix.

by regurgitation as if they were workers. They usually submit to these effusive attentions passively, but at times they may be seen to struggle and disengage themselves from the embraces of their hosts. When fully mature both sexes of the *Orasema* become highly phototropic and endeavor to escape from the dark nest to the open air and sunshine. The ants, however, redouble their attentions and carry them back to the dark chambers. Although usually aided by the workers in hatching from their pupæ, the *Orasemæ* themselves often remove the pupal envelopes from their antennæ by rubbing them with their fore legs, and, though fed by the ants, they sometimes visit and partake of the sugar in artificial nests. They spend much of their time in lying on their sides among the ant larvæ and pupæ. While the workers thus appear to be infatuated with their beautifully sculptured and brilliantly colored parasites, the latter are not sufficiently hypocritical to feign any interest in their hosts. They are, in fact, interested only in the ant brood and, as I shall show, only in a certain portion of the brood.

As several successive broods of *Orasema* pupæ appeared and hatched in my artificial nests, I was sure that the larval stages must also be present. These stages, it would seem, should be readily detected, but for a long time I was completely misled in my search for them, and even after I had found them, I was deceived by their appearance. This arose partly through certain prepossessions based on analogy with what I had read about other Chalcidids, and partly through the confusion produced by the high degree of polymorphism in the *Pheidole*. As nearly all Chalcidid larvæ are internal parasites in other larvæ, I was under the impression that the *Orasemæ* also start their life cycle within the larvæ of their hosts, and certain peculiarities in the *Orasema* larvæ merely tended to strengthen this prepossession. The great number of larval and pupal forms of the ant added to my confusion, especially as some of their larvæ differed in shape according to their feeding. Thus for a time I regarded certain small, spherical, sexual larvæ, fed with regurgitated liquids, as the young larvæ of *Orasema*. It was not till after I had left Texas and had nothing but preserved and stained material at my disposal that I succeeded in gaining a clear idea of the early larval stages of the parasite.

I have not seen the eggs of *O. viridis* after oviposition, but only the very young larvæ. Dissection of the female shows that, as we should expect in a parasite, the eggs are extremely numerous and minute. The mother insect, when she comes to oviposit, exercises a very careful selection among the ant brood. In the first place she has nothing to do with the *instabilis* larvæ but directs her attention to the pupæ. In the second place she selects, as a rule, only the pupæ of the soldiers, males, and females. The small worker pupæ would not furnish sufficient food for her larvæ. In the third place she selects

only pupæ at the very critical moment when they have just been stripped of their larval skin by the workers and are, therefore, little more than semipupæ, for obviously at this moment the cuticle is thinner and will be more easily pierced by the young *Orasema* larva than during the preceding or succeeding stages. And in the fourth place, she does not lay her eggs at random anywhere on the body of the semipupa but carefully selects one of four regions near the head. Usually she places the egg on the sternal surface just beneath the still very short, incurving legs of the semipupa but occasionally it is placed on the back of the neck between the head and the prothoracic segment, or on the right or left side of the neck beneath the corresponding prothoracic leg. These regions would seem to be singularly appropriate, both because the cuticle of the semipupa is extremely thin and readily punctured by the parasitic larva at these points, and also because the egg or resulting larva, especially when it is covered with the overlapping appendages of the semipupa, is not so readily brushed or licked off by the *instabilis* workers. I believe that the danger of detaching the egg is very great and this, together with the other special requirements above enumerated, may account for the fact that comparatively few of the great number of *Orasema* eggs ever complete their development.

Further reflection shows still greater appropriateness in the time and place selected for oviposition by the mother *Orasema*. In the sexual semipupæ of *instabilis*, and especially in those of the soldiers, the small anterior end of the body is destined to grow very rapidly and to undergo extraordinary changes in structure. For this purpose carefully elaborated liquid substances of a very high nutritive value are suddenly propelled into the anterior portion of the body of the semipupa, which therefore appears tense, clear, and transparent in this region, while the abdominal region is full of opaque, nonmetabolized fat cells. The parasitic larva is thus situated from the first at a point where it has ready access to a rich food supply and is able to grow with surprising rapidity.

The instinct that leads the mother *Orasema* to oviposit with such precision is not, however, infallible. As the number of soldier and sexual pupæ in an *instabilis* colony is always very limited compared with the number of worker pupæ, the *Orasema*, impelled, apparently, by the need of getting rid of her eggs, sometimes oviposits on the latter, although even in such cases also, she chooses the cervical and sternal region. The interesting consequences of this instinct aberration will be considered in a later paragraph.

Several of the youngest *Orasema* larvæ seen are represented in Plate II, Figs. 30–35. They are extremely small — less than .1 mm. in length — and of a dark brown color. The head is distinct and furnished with short,

acute mandibles; the body consists of a number of sharply marked segments, of which the anterior are longer and broader, the posterior smaller and often telescoped into one another so that it is difficult to ascertain their exact number. There are probably three thoracic and ten abdominal segments. The terminal segment bears a pair of hair-like cerci. Were it not for the absence of legs, these larvæ might be regarded as campodeiform and likened to the youngest stages of such parasites as the Stylopidæ and Meloidæ. Several of my preparations show these larvæ attached to the necks of worker semipupæ or pupæ, as represented in Plate II, Fig. 13. Twice I have seen a pair of these larvæ attached symmetrically on the sides of the same pupa. In other cases they were found on the nuchal or sternal surfaces.

So different are these minute, sharply segmented and dark brown larvæ from those of other Chalcidid larvæ, of which I have seen descriptions or figures, that I should never have regarded them as belonging to the life-cycle of *O. viridis,* had I not seen stages like those represented in Plate II, Figs. 14 and 15. These figures represent semipupæ of *instabilis* soldiers with undoubted *Orasema* larvæ .3 mm. in length attached, in the one case to the sternal surface between the pro- and mesothoracic segments, in the other to the nuchal surface. In Plate II, Fig. 14, the larva has its long axis at right angles to that of its host; in Fig. 15 the parasite and host are similarly oriented. The dark brown segments of the younger larva are represented in both cases by dark bands on a yellowish white background. The cerci have disappeared. The larvæ have plunged their mandibles into their host and have begun to absorb its juices, and this has led to a separation of the more heavily chitinized sclerites and great expansion of the intervening membranes.

Succeeding stages in the growth of these larvæ are shown in Plate II, Figs. 16, 17 and Plate V, Fig. 66. All of these represent female semipupæ of *instabilis,* and in each the *Orasema* larva, which is attached as in Fig. 14, has attained a length of .7–.9 mm. In Plate II, Fig. 17, which is drawn from a stained and mounted specimen, the parasite is somewhat shrunken through dehydration and clearing, but in Fig. 16, from an alcoholic specimen, the skin of the larva is smooth and tense. The fact that all traces of the dark bands have disappeared is probably due to the intervention of an ecdysis between this stage and the one represented in Figs. 14 and 15. It was stages like Figs. 16 and 17, which were first seen in my artificial nests and led me to an erroneous interpretation. The parasite in this stage was yellowish and semitransparent, while the semipupa to which it was attached was opaque, waxy white and more or less shriveled. The larva, moreover, seemed to make its appearance very suddenly, and this, coupled with the fact that the ants kept licking it till its surface glistened with saliva, led me to

suppose that it had reached its full growth within the ant-larva and was just breaking through the integument on the nuchal or sternal side. I saw the workers, which evinced the greatest interest in this phenomenon, pull the larva away from the semipupa and throw aside the latter, now reduced to a sickly mass, though still retaining enough of the contents of the abdomen and of its original form to be recognizable as a pupa, notwithstanding the fact that the head, as shown in Fig. 16, was much smaller than in the corresponding stages of the nonparasitized soldiers and females.

Shutting my eyes to the correct interpretation of the above stages as indicating that the larva was ecto- instead of entoparasitic, I stained and mounted *in toto* whole series of soldier and female larvæ and young pupæ in the hope of finding the *Orasema* larvæ prior to their eruption. This search proved, of course, to be futile, and I was baffled until I accidentally found the crucial stages represented in Plate II, Figs. 13 to 15.

The growth of the parasite, after it has plunged its mouthparts into the integument of its host, must be extremely rapid. I doubt whether the stages above described require more than a couple of days for their completion. Such rapid growth, however, is not surprising when we consider the accessibility and high nutritive value of the food on which the larva subsists.

As soon as the full-grown *Orasema* larva has been separated from its prey, it begins to pupate. Occasionally the ants are either unable or neglect to detach the parasite. In such cases, two of which are shown in Plate II, Figs. 18 and 19, the larva begins to pupate *in situ*. It undergoes an ecdysis in which it is undoubtedly assisted by the workers, and then appears as a short, thick-set semipupa, slightly constricted just in front of the middle of its body. Another ecdysis seems to follow almost at once, leaving the semipupa covered with a peculiar envelope studded with large blisters, or pustules. These are arranged segmentally in regular rows along each side of the body but are absent in the middorsal and midventral regions. I am unable to assign any function to these singular organs, which in *O. viridis* disappear with the semipupa stage. On focussing through the pustulate envelope the semipupa is seen to present the appearance of Fig. 20 (Pl. II). The imaginal head, with its large eyes and antennæ, is embedded in a hood-like prothoracic mass; the legs and wings are clearly indicated. A little later the pustulate envelope is shed and the complete, pure white pupa of the *Orasema* is seen enclosed in a thick membrane (Pl. II, Fig. 22) which, in the intersegmental regions of the abdomen, is thrown into prominent transverse welts. The color, which now gradually deepens, becoming first blackish and then metallic green, is dimmed by the rather opaque, white pupal envelope (Pl. II, Fig. 23). Soon after this stage is reached, the

insect hatches. The changes from the stage represented in Fig. 21 to that of Fig. 23 can hardly require more than three or four days. If this and my estimate concerning the rate of development in the earlier stages is correct, we must suppose that *O. viridis* completes its entire life-cycle, from the egg to the imago, in less than a week or ten days. Similarly rapid developments are known to occur in other Chalcidids, as I infer from the following statements in an interesting paper published some years ago by Howard[1]: "Ratzeburg has shown that in Europe *Pteromalus puparum* occupied on one occasion from June 11 to July 14 to undergo its entire transformation from egg to adult — thirty-seven days; but in this country Webster has recorded an instance (Insect Life, I, 225) in which the eggs of the same parasite were laid August 9, the adult insect developing August 27 — seventeen days later. Hubbard has noted (Fourth Report U. S. Ent. Com., p. 103) that the egg of *Aletia xylina* gives forth the adults of *Trichogramma pretiosa* on the seventh day after it was stung by its parents. *Euplectrus comstockii* has been shown by Schwarz to develop from egg to adult in Alabama in midsummer in seven days."

There can be little doubt that in a state of nature the male and female *Orasemæ* leave the nest very soon after hatching and mate in the open fields. This is indicated by their strong positive phototropism. The fertilized females then seek out fresh *Pheidole* nests in which to lay their eggs. In one of my artificial nests, however, which was kept from June 19 to September 20, three successive broods of *Orasema* were noted, the last disappearing about a week before the latter date. In this case, unless the offspring arose from parthenogenetic eggs, the males and females must have mated in the nest. Both in this and other cases it was found that the adult *Orasemæ*, after they had remained in the nest for several days, were killed and dismembered by the workers, as though the parasites had at last been recognized as predatory aliens. This slaughter, however, may have been due to other causes, since the workers also killed and dismembered their own females and ultimately reared only workers and intermediates, probably because these required less nourishment. Such conditions point to a deterioration of the colony and are frequently observed in artificial nests inadequately furnished with food. Similar behavior on the part of workers may be seen in other species of ants when the food supply becomes insufficient or is no longer palatable. Under these circumstances I have seen *Camponotus ferrugineus* workers kill and dismember their soldiers and *Myrmica brevinodis* workers do away with their males.

Before concluding this account of the relations of *O. viridis* to *Ph.*

[1] The Biology of the Hymenopterous Insects of the Family Chalcididæ. Proceed. U. S. Nat. Mus., XIV, 1892, pp. 567–588.

instabilis, it will be necessary to return to the worker semipupæ on which the *Orasema* occasionally deposits her eggs. In such cases the young larvæ of the parasite must be very inadequately fed and probably soon die and fall off, leaving their hosts in a depleted condition but still able to pass on to the pupal stage. Now in all the nests infested with *Orasema*, and only in these, I have found a number of peculiar pupæ like those represented in Plate II, Figs. 24–26 and Plate V, Fig. 65 *s*, and differing from the normal worker pupæ (Fig. 27) in several important characters. They are smaller, of a waxy white color, with more decided intersegmental constrictions and are broad behind and very narrow anteriorly. The head is remarkable for the very small size of the brain and eyes and the situation of the latter on distinct stalks. The mandibles, too, are abortive. The resemblance of the head to depleted female pupæ, like the one represented in Fig. 16, is very striking. The thorax is extremely slender and the gaster has a high fold on each side, and in balsam preparations (Pl. II, Fig. 26 and Pl. V, Fig. 67 *i*) is seen to contain a number of large urate masses in the *corpus adiposum*. In many specimens the gaster is concave ventrally, with its tip turned upward and forward. Although these singular pupæ are carefully cleaned by the workers and kept with the normal individuals, they never succeed in hatching. After lying in the chambers for many days without even acquiring a deeper color of the body or pigment in the eyes, they are either carried to the refuse heap or eaten by the workers. I am convinced that these extraordinary pupæ, which may be called *phthisergates*, have arisen from worker semipupæ that have had part of their juices sucked out by *Orasema* larvæ, so that only enough formative material was left to produce pupæ with very defective head and thorax and hence quite unable to develop as far as the imaginal instar. It is interesting to note that these microcephalic, microphthalmic, and stenonotal characters represent merely greater diminution of the similar characters of the normal workers as compared with the more macrocephalic, macrophthalmic, and eurynotal soldiers and females. The theoretical bearings of these conditions will be considered in the latter part of this article. The depleted semipupæ of the *instabilis* females and males, which like the phthisergates are incapable of further development, may be called *phthisogynes* and *phthisanērs* respectively.

In this connection the question naturally suggests itself: are the intermediates between the *instabilis* workers and the soldiers due to similar depletion in their semipupal stages? In other words, do the intermediates arise from soldier semipupæ that have been partially exhausted by *Orasema* larvæ prematurely torn from their hosts by the workers? I am inclined to answer this question in the negative, for reasons to be given in the sequel.

After finding *O. viridis* so common in the nests of *Ph. instabilis* I was

naturally led to look for it in the company of other Texan species of *Pheidole*. This search soon revealed the fact that the parasite can make its home also with other ants of this enormous genus. June 16, I found a single female *viridis* in a flourishing colony of *Ph. dentata* Mayr at Alice, Texas, which is only about ten miles east of San Diego where the types of the parasite were originally captured by Schwartz. *Ph. dentata*, it should be noted, is a carnivorous species with sharply separated soldier and worker castes, as represented in Plate III, Figs. 37 and 38. June 21, I again found at New Braunfels, Texas, a colony of this same *Pheidole* containing a few female pupæ of *O. viridis*. In this colony, which was kept for some weeks in an artificial nest, four phthisergates made their appearance. One of these is represented in Plate II, Fig. 28. They differed considerably in form from the *instabilis* phthisergates and had slightly pigmented eyes. These organs, however, as well as the head and thorax were notably reduced as compared with those of the normal worker pupa, which is essentially like that of *instabilis* (Pl. III, Fig. 27).

A little later in the month (June 24), I came upon a colony of a hitherto undescribed *Pheidole* (*Ph. sciophila* sp. nov.), containing a number of imagines and pupæ of *O. viridis*. This ant, like *Ph. dentata*, has no forms intermediate between the soldiers and workers. It is a rare species, nesting under stones in rather damp, shady places in the vicinity of Austin. These observations prove that *O. viridis* is not confined to a single host ant but has international relations with a number of species of the genus *Pheidole* in central and southern Texas. It may be expected to occur also in the nests of *Ph. crassicornis*, *Ph. hyatti*, *Ph. morrisi*, etc. Still another observation goes to show that the parasite is not confined to Texas, but is also probably widely distributed through Mexico. In my collection there is a female specimen of *O. viridis* taken August 4 at Tuxpan, in the state of Jalisco, by Mr. J. F. McClendon. As this specimen was found in a bottle containing a mixed lot of ants comprising three species of *Pheidole*, besides some species of other genera, I am unable to refer it to a particular host.

B. Orasema coloradensis Ashmead.

During August, 1903, while collecting ants in Colorado, I came upon a second species of *Orasema*, which Dr. Ashmead has identified for me as *O. coloradensis*, in the nests of two very different species of ants. One of these is a larger and usually darker form of a small *Solenopsis*, which I take to be *S. molesta validiuscula* Emery, the other *Pheidole vinelandica* Forel.

O. coloradensis (Pl. I, Fig. 12 and Pl. V, Fig. 68 *m*) is of about the same size as *O. viridis*, but is readily distinguished by its longer, lower, and

smoother thorax, and less prominent scutellum and epinotum. In coloration it is like the Texan species, except that the thorax is less golden above and the mesopleuræ are more shining. In the male the petiole is shorter and the tibiæ are more or less infuscated. The mature pupæ of the two species are very readily distinguished by the character of the last pupal envelope. In *coloradensis* (Pl. IV, Figs. 53 and 54) this is pustulate like the semipupal envelope of *viridis*, the pustules appearing on the abdomen as dilatations in the transverse intersegmental welts above described for *viridis*. Then, too, the pupal skin of the Colorado species has a series of large pustules extending along the middorsal line of the epinotum and abdomen and about the front of the pronotum where they are completely absent in *viridis*.

O. coloradensis was first noticed August 3, in a colony of *S. validiuscula* (Pl. V, Fig. 68) at Manitou. The ants with their brood were confined in a bottle for the purpose of rearing some of their numerous male and female pupæ. The tiny workers were seen to spend much time shampooing an adult female *Orasema*. Later other females and a few males hatched in the nest and were cared for by the ants like members of their own species. In the course of a few days two of the *Orasemæ* were found dead on the refuse heap, one having been decapitated and shorn of its legs and wings. This led me to wonder whether the *Solenopsis* workers which are themselves parasitic and feed on the larvæ and pupæ of other much larger ants of the genera *Formica, Myrmica, Cremastogaster*, etc., are quicker than the species of *Pheidole* to recognize the *Orasemæ* as aliens after they have been reared. August 11, while collecting near Broadmoor, south of Colorado Springs, I found two more infested *Solenopsis* colonies. This *Solenopsis* was paler than the form taken at Manitou, and in this respect approached the typical *molesta*. In one of these colonies I counted twenty pupæ and adult *Orasemæ*. At the same time I noticed that there were very few male and female pupæ of the ant. The other colony, which contained nearly as many of the parasites, was living in cleptobiosis with a large colony of *Formica ciliata* Mayr. As *S. molesta* has only one form of worker, and this of minute size compared with the males and females and since, moreover, the males and females of *O. coloradensis* are of about the same size as the corresponding sexes of the ant, I infer that the larvæ of the parasite must feed exclusively on the sexual forms, while the tiny workers enjoy complete immunity from their attacks.

In the same locality in which I saw the *Solenopsis* nests above described, and on the same day, I found two colonies of *Pheidole vinelandica* containing the same species of *Orasema*. One of these colonies was taken alive and placed in a Fielde nest. A careful examination of the worker brood revealed the presence of a single phthisergate with somewhat pigmented eyes and

very similar in shape to those of *Ph. dentata* above described. This phthisergate had neither hatched nor changed its appearance by August 29 — 15 days later. It eventually disappeared (eaten by the workers?). The colony was kept for several weeks but as no second brood of *Orasema* appeared, it was abandoned. August 20 I found near Beaver Ranch, southeast of Colorado Springs, a third infested *vinelandica* colony. This two was kept in an artificial nest, but the observations revealed nothing that has not been recorded for *Ph. instabilis* and *O. viridis*. According to Forel, *Ph. vinelandica* occasionally produces intermediates between the typical soldiers and workers, but although I have collected many colonies of this ant in different parts of the United States, I have seen only the typical soldiers and workers.

The foregoing observations prove that *O. coloradensis*, like *O. viridis*, does not confine its depredations to a single host ant. It may be said to be even more catholic in its habits, since it not only infests a species of *Pheidole* but also attacks ants belonging to the very different genus *Solenopsis*. The number of colonies observed was not sufficient to show which of these genera represents the original and more frequent host, but, judging from analogy with *O. viridis* and the next species to be considered, there can be little doubt that this is *Ph. vinelandica*. *O. coloradensis* probably occurs also in the nests of *Ph. pilifera* var. *coloradensis* and *Ph. ceres*, both common ants in the neighborhood of Colorado Springs and other localities of about the same altitude.

C. Orasema wheeleri Ashmead.

A third species of *Orasema*, which Dr. Ashmead will describe as *O. wheeleri*, was found July 14, 1902, on Keesy's Ranch at Fort Davis, Texas, in the nest of *Pheidole ceres* Wheeler. This ant is a small, dark colored species which makes obscure nests in the shade of the cotton-woods (*Populus fremonti*) and garners the woolly seeds of these trees. The *Orasema* was seen in only one of the nests, and though about a dozen pupæ were found among the ant brood, only a single mature specimen, which happened to be a female, could be secured. It measures 2.7 mm. and closely resembles *O. viridis*, especially in the shape of the scutellum and epinotum, but the thorax is broader and stouter. The last pupal envelope, like that of *viridis*, is without pustules, though it has strong intersegmental welts in the abdominal region.

I have examined many colonies of *Ph. ceres* near Fort Davis and in various Colorado localities without finding any intermediates between the soldiers and workers. In the single colony infested with *O. wheeleri*, how-

ever, there were several of these annectant forms. As this could hardly be a mere coincidence, we must assume that there is some connection between the existence of intermediates and the presence of the parasites.

D. Other Chalcidid Ant-Parasites.

From the observations recorded in the above paragraphs we may safely conclude that the remaining *Orasema* species, of which quite a number have been described by Cameron, Howard, and Ashmead, are parasitic on ants and have life-cycles analogous to that of *O. viridis*. Still other genera, however, of the enormous family Chalcididæ, contain ant-parasites and these, though very imperfectly known, may be passed in review before I proceed with an account of a very different type of parasitism. For the sake of convenience we may distinguish three groups of cases, first the ant-parasites of the sub-family Eucharinæ exclusive of *Orasema*, second those belonging to other subfamilies, and third, the cases too imperfectly known to be referred to any particular genera.

Among students of the Chalcididæ the opinion seems to have been gaining ground that the Eucharinæ, which according to Ashmead's recent synopsis (l. c. pp. 266–270) comprise some 25 genera, are largely, if not exclusively ant-parasites. Ashmead says that in this group "are found some of the most singular looking and wonderfully shaped Chalcids known, the structure of the thorax, and particularly of the scutellum, being most wonderfully and curiously modified and developed; and this development, in connection with the brilliant metallic green and blue colors of its members, makes the group the most striking and attractive of any in the subfamily. Some of the species are now known to be parasitic upon ants and probably the whole group attacks these insects. In temperate regions the family is poorly represented, but in tropical countries, where ants most abound and flourish in enormous colonies, these insects are not rare and seem to have reached a very highly specialized development." This extraordinary specialization, which at once reminds us of that obtaining in other highly myrmecophilous and termitophilous groups, like the Paussidæ among beetles and the Termitoxeniidæ among Diptera, etc., is clearly shown in the figures of some of the more striking Eucharine genera reproduced in this article (Pl. IV, Figs. 56–62).

The first to describe a Eucharine parasite on ants was Forel.[1] On opening the huge cocoons of one of the Australian bull-dog ants (*Myrmecia forficata*) he found several metallic green and coppery pupæ about a cm. long, which a year later were described and figured by Cameron[2] as those

[1] Un parasite de la Myrmecia forficata Fabr. Extr. C. R. Soc. Ent. Belg., I Fev. 1890, 3 pp.
[2] Hymenopterological Notes. Mem. Lit. Phil. Soc. Manchester (4), IV, 1891, pp. 182–194, 1 pl.

of *Eucharis myrmeciæ*. These pupæ, according to Forel, were "couvertes d' aspérités et de boursoufflures," probably analogous to the pustules above described for the pupa of *Orasema*. He concluded that the *Eucharis* attacks the *Myrmecia* larvæ, but after what I have said of *Orasema* it is more probable that the Chalcidid attacks the semipupa or pupa of the ant after the cocoon is spun and encloses both host and parasite.

In the same paper in which the *Eucharis* is described, Cameron describes a member of another genus, *Chalcura bedeli*, which was taken in nests of the Algerian *Myrmecocystus viaticus*.

Wasmann in his 'Verzeichniss', published in 1894,[1] cites as the only Chalcidids known to occur with ants the two preceding species described by Cameron and a *Chalcura* sp. which was "bred from cocoons of *Formica rufa* at Prag (Polak)."

Another Chalcidid belonging to the subfamily Eucharinæ and closely related to the preceding, was accidentally detected in some alcoholic material of *Camponotus ligniperdus* var. *novæboracensis* Fitch, collected August 12, 1904, on a bare slope of the Porcupine Mountains in northern Michigan by Mr. Otto McCreary and sent me for identification by Dr. Charles C. Adams. Two of the worker cocoons, measuring respectively 6.5 and .7 mm., were found to contain pupal parasites, which Dr. Ashmead has identified for me as *Pseudochalcura gibbosa* Provancher. In one of the cocoons, represented in Plate II, Fig. 29, there were two pigmented and therefore nearly mature pupæ, lying face to face near the anterior pole, while the remains of the ant pupa, which they had consumed, were crowded against the black meconial spot at the posterior pole. The other cocoon contained four unpigmented pupæ. It would seem that the Chalcidid larva must attach itself to the *Camponotus* larva and wait till it has spun its cocoon, before devouring the host. As the ant is an unusually large species compared with the parasite, several of the latter can obtain sufficient nourishment even from a single worker and need not, like *Orasema*, attack the still larger intermediate, soldier, and female brood.

I have received with some miscellaneous ants (*Formica fusca* var. *neorufibarbis*, *Myrmica brevinodis*, etc.) collected by Mr. H. Viereck, on the summit (11,000 ft.) of the Las Vegas Range, New Mexico, a single male specimen of a *Eucharis* (Pl. IV, Fig. 62), which is in all probability an ant parasite, although I am unable to refer it to its precise host.

In the discussion following a paper read several years ago by Ashmead before the Entomological Society of Washington,[2] Howard called attention

[1] Kritisches Verzeichniss der Myrmekophilen und Termitophilen Arthropoden. Berlin, 1894.

[2] Notes on the Eucharids found in the United States. Proc. Ent. Soc. Wash., II, 1890–92, pp. 354–358.

to the fact "that in the collection of St. Vincent Chalcids sent to Professor Riley from Cambridge University there is a specimen of *Kapala furcata* Fabr. which bears in its jaws a medium sized red ant." Events have shown that Howard was probably correct in supposing this peculiar Chalcidid to be an ant parasite. Dr. O. F. Cook informs me that he has bred a specimen of an allied genus, *Isomeralia coronata* Westwood (Pl. IV, Figs. 58 and 59), from a cocoon of the Guatemalan kelep (*Ectatomma tuberculatum* Oliv.), and Dr. Ashmead tells me that in his opinion *Kapala floridana* (Pl. IV, Figs. 56 and 57) is probably parasitic on the Florida harvester (*Pogonomyrmex badius* Latr). He also assures me that the type of *Pseudometagia schwarzi* was taken in an ant-nest near Washington, D. C.

To the foregoing observations on Eucharinæ I am able to add some notes on a parasite belonging to another subfamily of Chalcididæ. As stated on p. 2, I failed to find *Orasema* in nests of *Pheidole instabilis* except during the summer and late spring months. At other seasons I often took a species of the subfamily Asaphinæ, namely, *Pheidoloxenus wheeleri* Ashmead (Pl. III, Fig. 36), an exquisite little Chalcidid which runs about in the dense throng of *Pheidole* workers like one of their number. It is not easily detected, as it resembles the workers in its small size (1 mm.) and in being subapterous or practically wingless. Its head is very wide, with a concave occiput and 9-jointed antennæ inserted near the oral border. These appendages are very robust, and have a club-shaped funiculus terminating in a broad flat joint. The epinotum is very short, the wings are represented only by the tegulæ and minute vestiges of the alar membranes. The surface of the body is smooth and shining. The head is deep metallic blue, with green cheeks and yellow mandibles; the antennæ are yellow at the base, with the large apical and adjacent transverse joints black. The thorax is green with golden reflections, the epinotum more blue green, the tegulæ violet. The abdomen is metallic green with a broad violet band across the posterior portion of each of the basal segments. The legs are fuscous, with yellow knees, tarsi and trochanters.

I have not been able to learn anything concerning the development of this insect. According to Ashmead the vast majority of Asaphinæ are parasites "upon plant lice, Aphididæ, and upon the bark lice, Coccidæ," but this cannot be the case with *Pheidoloxenus* since this insect is a regular myrmecophile, and *Ph. instabilis* does not, like our northern species of *Lasius*, cultivate aphids and coccids in its nests. During the autumn and winter months I have occasionally seen the *instabilis* workers carrying small pink larvæ about in the chambers. These were certainly not a portion of the ant brood, but whether they were the larvæ of *Pheidoloxenus* or not, I have been unable to determine. On one or two occasions I have seen as many as six or eight

of the little Chalcidids in a single nest. A careful search will probably show that they are even more abundant.

In the literature I find the following scattered references to Chalcidid ant-parasites:

Fritz Müller, according to Sharp,[1] mentions a South American Chalcidid which attacks the larvæ of *Azteca instabilis* in its nests in the Cecropia trees. When the parasite pupates it suspends itself, by its posterior end, from the walls of the chambers like a butterfly chrysalis.

Wasmann[2] cites an observation of Brauns who found a Chalcidid in one of the nests of a South African subspecies of *Pheidole megacephala*. When the nests were disturbed the workers were seen to carry the parasites, which probably devour the brood, to a place of safety.

A larva found by Rupertsberger attached to a large *Myrmica* larva, and mentioned by Wasmann in his 'Verzeichniss' (*l. c.*, p. 169) as possibly an Ichneumonid, was probably a Chalcidid.

Perhaps no single group of parasitic insects has greater surprises in store for the future investigator of habits and development than the Chalcididæ. This is indicated not only by the fragmentary materials collated in the preceding paragraphs, but more especially by the splendid researches of Bugnon,[3] Marchal,[4] and Silvestri,[5] on the extraordinary polyembryony of the Encyrtinæ. These and future researches in the same direction may be expected to bring about many radical changes in the present taxonomy of the enormous family Chalcididæ.

2. The Parasitism of Mermis in Ants.

Five years ago (June 3, 1901), I found at New Braunfels, Texas, on a shady hill that slopes to the lovely sources of the Comal River, two medium-sized colonies of *Pheidole dentata* var. *commutata* Mayr. They were under stones about sixty feet apart. One contained ants of the typical dark variety of the species, while both the soldiers and workers of the other colony were decidedly paler. On lifting the stones my attention was arrested by several very large and conspicuous individuals with huge gasters, moving about among the workers and soldiers of normal dimensions. Unfortunately I failed to preserve any living specimens at that time but collected instead a

[1] Cambridge Natural History. Insects, Vol. I, 1895, p. 550.

[2] Die Psychischen Fähigkeiten der Ameisen. Zoologica, Heft 26, 1899, pp. 1–132, Taf. i–iii.

[3] Recherches sur le Développement postembryonnaire, l'anatomie et les mœurs de l'Encyrtus fuscicollis. Recueil Zool. Suisse, V, 1891, pp. 435–534, pl. xx–xxv.

[4] Recherches sur la Biologie et le Développement des Hyménoptères Parasites. I, La Polyembryonie Spécifique ou Germinogonie. Arch. Zool. Expér. (4), II, 1904, pp. 257–335, pl. ix–xiii.

[5] Sviluppo dell' Ageniaspis fuscicollis (Dalm.) Thoms. Rendic. R. Accad. Lincei, XV, 1906, pp. 650–657.

number of specimens in alcohol. These were described in a paper published during the autumn of 1901.[1] In this paper the huge workers were called macroërgates, but for reasons presently to be given they may be more aptly designated as mermithergates.

Plate III, Figs. 37–40 represent, drawn to the same scale, the dorsal view of the soldier and worker, which in *Ph. commutata* are not connected by intermediates, and the dorsal and lateral views of a large mermithergate. The length of normal workers does not exceed 3 mm. Many of them are scarcely more than 2.5–2.8 mm., which was the length of Mayr's type specimens from Florida. The largest mermithergates, however, measured fully 5 mm., while the smaller ones varied from 4 to 4.5 mm. Thus the volumes of the normal workers and the extreme mermithergates, had they been of the same shape, would be in the ratio of 27 to 225, but the gasters of the latter were so enormously distended that the ratio must have been 27 to at least 300. In other words, the large mermithergates were some twelve times as large as the normal workers. They were even larger than the soldiers, which measure about 4 mm., though in this case, owing to the great size of the head in the latter caste, the difference is less conspicuous. The largest mermithergates differ from both soldiers and workers in usually possessing three ocelli, of which the anterior is the largest, and resemble the soldiers in the structure of the thorax (Pl. III, Fig. 39).

Examination of one of these extraordinary individuals, even with a good pocket lens, reveals the cause of the great enlargement of the gaster. Through its distended intersegmental membranes the coils of a parasitic worm may be distinctly seen. My friend Professor T. H. Montgomery, to whom I sent a few of the mermithergates, writes me that the parasite is a species of *Mermis*. Its exact location among the ant's viscera, *i. e.*, whether it occupies the lumen of the enormously distended ingluvies, or lies in the body cavity outside of the alimentary tract, is not easily determined. From careful dissection of a single large specimen (the one represented in Pl. II, Fig. 39) I concluded that the *Mermis* lies within the ingluvies, or crop. In this specimen the head of the parasite extended forward through the postpetiolar and into the petiolar segment, and thus occupied the attenuated neck of the crop and the most favorable position for securing the ingurgitated food of its host. The fat-body and reproductive organs seemed to have disappeared completely and the walls of the enormously distended crop were practically in contact with the walls of the gaster. The large mermithergate shown in Figs. 39 and 40 contained only a single closely convoluted *Mermis*, which was fully 50 mm. long, or ten times the length of the ant. One

[1] The Parasitic Origin of Macroërgates among Ants. Amer. Naturalist, XXXV, Nov. 1901, pp. 877–866, 1 fig.

individual, dissected by Professor Montgomery, contained two somewhat smaller parasites, together with many of their eggs. I have seen specimens containing as many as six and eight parasites. The specimens dissected by Professor Montgomery were "either fully mature or in what von Linstow[1] calls the second larval stage, which is, however, really the immature stage."

While it is certainly somewhat singular that a species of *Mermis* should occur in ants, even greater interest attaches to the cases under discussion, on account of the manifest effects of the parasite on its host. The fact that all the mermithergates are of huge size as compared with the normal workers is remarkable, for, on first thought, one would certainly expect an animal infested with such large parasites to be stunted, or, at any rate, below the average stature of the species. This paradoxical condition of the mermithergates of *Ph. dentata* is easily understood, however, when we make due allowance for certain peculiarities in the behavior of ants. In the first place, it is obvious that the parasite must enter the body of the ant while she is still a larva. This was proved by the fact that two of the large mermithergates were callows, one of them still very soft and pale yellow, the other with harder integument but without the deep coloration of the mature workers. Such huge parasites could scarcely have made their appearance in ants so recently escaped from their pupal envelopes. But even if there had been no callows among the mermithergates, the truth of the above statement would still be patent, both because the mermithergates were all infested while none of the normal workers were found to contain parasites, and because the structure of an ant is, of course, fixed in the pupal stage and cannot be subsequently increased to the dimensions of the insects under consideration.

It is evident, furthermore, that the larger stature, which is very apparent not only in the distended gaster of the mermithergates, but also in all the other parts of the body, can have its origin only in an unusually large amount of food consumed during the growth period of larval life. Now *Ph. commutata* is exclusively carnivorous and feeds at least its older larvæ with pieces of insect food. The workers cannot, therefore, accurately regulate the amount of food consumed by each larva, and it must be possible for larvæ infested with parasites, and hence presumably endowed with a more voracious appetite, to consume a greater quantity and hence produce larger pupæ and imagines than unparasitized individuals. If this inference is correct we must suppose that the stimulus to the increased feeding, *i. e.* the appetite, which results in the larger stature of the mermithergate, resides

[1] Das Genus Mermis. Arch. f. mikr. Anat., LIII, 1898, pp. 149–168, Taf. viii.

in the larva and cannot be accurately controlled by the worker ants. The theoretical bearings of these considerations will be postponed to a subsequent portion of this article.

Two years later (June 21, 1903), on revisiting New Braunfels I found on the very same hill slope two more colonies of *Ph. commutata* containing mermithergates. On this occasion every effort was made to secure the entire personnel of the colonies in a living condition. One colony, confined in too small a bottle, died before I reached my home, the other was successfully transferred to an artificial nest. On examining the asphyxiated colony I found it to consist of many female larvæ and pupæ, a few soldier and several worker larvæ and pupæ, and a dozen mermithergates which varied considerably in size from individuals but little larger than the workers and without ocelli, to huge individuals like those taken two years previously. These large mermithergates possessed ocelli, a thoracic structure like the soldiers and a rich red color like the females. Three pupal mermithergates were also found but their gasters were not distended. The earth of the nest contained two free *Mermithes*.

The personnel of the living colony comprised six adult and three pupal mermithergates, a winged and several pupal females, and a number of larval, pupal and adult workers and soldiers. All of the pupal mermithergates, like those in the asphyxiated colony, had the gaster in proper proportion to the remainder of the body, so that they appeared to be merely gigantic worker pupæ. One of these hatched June 24, the two others July 2. As soon as they had hatched, their gasters began to enlarge rapidly and in the course of a few days the coils of the *Mermis* became visible through the distended pellucid membranes between the widely separated segmental sclerites. Evidently the parasites were present but of very small size in the pupæ and grew very rapidly during the callow stages of their hosts while the chitinous investment of the gaster was still soft and distensible. This sudden growth of the parasite is probably due to the rich and abundant food with which the recently hatched callow is supplied by her sister workers.

This colony of *Ph. commutata* was kept under observation till August 12. Of the nine mermithergates which it contained, three had died by June 27, and three more by July 19, while the nest was being transported in my hand luggage from Texas to Colorado. Of the surviving three, two died July 25 and 30 and the last August 12. Hence, at least one of these parasitized ants must have lived fully six weeks in the imaginal stage. In all of these cases the *Mermis* died within its host and both were carried to the refuse heap by the workers. One of the dead mermithergates had burst and the loops of the parasite protruded. In a state of nature it probably escapes from its host at this or an earlier stage, and enters the soil for the purpose

of laying its eggs. Or the eggs may, perhaps, be discharged into the alimentary tract of the ant and escape with its excrement. It is not difficult to conceive how they may find their way into the young larva. They may adhere to the body of the workers till gathered up by their strigils or tongues and transferred to the buccal pocket. Thence they could be fed inadvertently to the larvæ, either with the regurgitated liquid food or with pieces of insects that had been malaxated and distributed by the workers.

The living mermithergates were easily studied in my artificial nest and exhibited several interesting peculiarities in their behavior. On exposure to the sunlight they hurried, like the females, to the dark chamber, thereby evincing a much higher degree of negative phototropism than the workers and soldiers. They never carried the brood, although even the soldiers were seen to do this occasionally. They never fed the larvæ, workers or females, and, had earth been present in the nest, it is very probable that they would never have shown any inclination to excavate. They never visited the manger of the nest but were fed exclusively by regurgitation. As befitted animals containing such enormous parasites they were in a chronic state of hunger. It was impossible at any time to uncover the nest without finding one or more of them either being fed by a worker or eagerly begging for food. And as soon as one was offered food, three or four of them would rush up and put out their tongues for a share of it. Once I saw a single worker trying to feed five of her huge parasitized sisters simultaneously. While imbibing their food the mermithergates stridulated, either continuously or at regular intervals. Sometimes they were so impatient to be fed that they would hold down a worker's head with their large fore feet and compel the little creature to regurgitate. Under these circumstances the larvæ must have been poorly fed, for the insatiable mermithergates continually intercepted the workers on their way from the manger to the brood chamber. The mermithergates in my artificial nest may have been massacred or starved by the workers and did not die merely as a result of parasitism for when the food supply becomes insufficient the tiny *Ph. commutata* workers, like those of *Ph. instabilis*, probably rid the colony of voracious and nonproductive mendicants, even when these belong to their own species. Apart from their chronic hunger, the mermithergates exhibited no abnormal traits of behavior directly attributable to parasitism. They ran about with as much alacrity as the workers and soldiers. Their other peculiarities, such as their strong negative phototropism, their dependence on regurgitated food, and the absence of the foraging instinct, like their large size, their ocelli and rich red color, may be regarded as female or soldier traits.

Mermithergates occur also, I believe, in two other Texan ants belonging

to the genus *Cremastogaster* (*C. minutissima* Mayr and *C. victima missouriensis* Pergande). Both are small honey-yellow species which nest under stones in shady places. From a colony of *minutissima* taken June 3, 1901, in the very same locality at New Braunfels as the parasitized colonies of *Ph. commutata*, I took three large workers which were described and figured by Miss Holliday as ergatoid females.[1] These measured 4.3–5 mm. whereas the normal workers of this species do not exceed 2 mm. They had small ocelli and greatly enlarged gasters, and though no parasites were found in them, it is not improbable that they contained young specimens of *Mermis* that may have been overlooked when Miss Holliday made her dissections for the purpose of ascertaining the condition of the ovaries.

In a lot of *C. victima missouriensis* collected by Miss Augusta Rucker at Paris, Texas, I have recently found four individuals resembling the *minutissima* mermithergates described by Miss Holliday. They measured 3.2 and 4.5 mm. respectively, although the normal workers measure only 2–2.5 mm. None of these mermithergates has ocelli. In the two largest specimens the gaster is very voluminous but seems to contain no parasites, and the mesonotum is unusually large and convex, so that the thorax resembles that of a pseudogynic *Formica*.

Recourse to the literature shows that Emery had seen mermithergates in certain Central American and South American ants as early as 1890. In his paper on a collection of these insects from Costa Rica he describes and figures two odd specimens of *Pheidole absurda* Forel from Alajuela.[2] They measured 7.25–7.75 mm., although the normal worker of this species measures only 2.75–3 mm. They had huge, elongated gasters, vestiges of ocelli, and a thorax similar to that of the soldier, but in the shape of the head they resembled the worker caste. He did not observe that they were parasitized but regarded them as "parthenogenetic females." In the same paper, and from the same locality, he also described three specimens of *Odontomachus hæmatodes* with a huge gaster and a minute ocellus, as possibly a new variety (var.? *microcephalus*).[3] In this connection he mentions three other similar cases: an *O. chelifer* (var.? *leptocephalus* Emery) from Rio Grande do Sul, a *Neoponera villosa inversa* from Venezuela, and another tropical American ant, *Ectatomma tuberculatum*. In all of these cases the great volume of the gaster was naturally attributed to an unusual development of the ovaries.

Since reading my paper Emery has reëxamined his specimens and finds

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[1] A Study of Some Ergatogynic Ants. Zool. Jahrb. Abth. f. Syst., XIX, 4, 1903, pp. 311, 312, 16 figs.

[2] Studii sulle Formiche della Fauna Neotropica. Boll. Soc. Ent. Ital. Ann., XXII, 1890, p. 49, pl. v, figs. 10 and 11.

[3] Emery calls attention to the fact that this form of *hæmatodes* had been previously seen by Roger.

that in all of them the enlargement of the gaster is due to *Mermis* parasites.[1] In addition to the above mentioned forms he also describes mermithergates in *Pachycondyla fuscoatra* from Bolivia, and in the well-known South American *Paraponera clavata.*

Both Emery (*l. c.*, p. 591) and Wasmann[2] object to my applying the name macroërgates to the *Pheidole* workers parasitized by *Mermis.* The latter author, who coined this term, applies it to "abnormally large workers with normal development of the gaster," and in another place,[3] to "individuals which approach the females abnormally in the size of the body, but in other respects (even in the development of the gaster) are normal workers." I am quite willing to be corrected, but it should be pointed out that the gaster in the adult pupæ of the mermithergates of *Ph. commutata,* and probably also of the other species, is normal in its proportions, the enlargement being confined to the imaginal instar. It is merely a mechanical dilatation such as is seen in the repletes, or plerergates of the honey ants (*Myrmecocystus*) and in Wasmann's "gynæcoid workers," which are merely workers whose ovaries contain mature eggs. Although the dilatation in these different cases is due to the difference in the contents of the gaster (liquid food, ovaries or parasites) the morphological results are the same. Even had the objection to the use of the term macroërgates been based on the presence of the ocelli, it would not have been greatly strengthened, for these may be absent in specimens to which the term would seem to be applicable. In my opinion it may be permissible to distinguish three classes of macroërgates, namely: macroërgates proper (as defined by Wasmann), mermithergates, and plerergates.

Emery adds to his observations an interesting hypothesis. He says (pp. 601–603): "I believe that the singular microcephaly of the worker ants infested with *Mermis* may be attributed to a general law of growth of the ant-body and perhaps also of the insect body in general.

"We must assume with Wheeler that the parasitic nematode enters the ant larva and has already attained a considerable size before its metamorphosis. As long as the larva retains its cylindrical, spindle, or clavate shape, the worm, no matter whether it is injurious to the growth and development of the larva or not, will have only a slight influence on the external form. But as soon as the constriction appears at the anterior end of the abdomen during the preparation for the pupal stage, and the whole worm is relegated to the latter region, the defective nutrition of the larva makes itself felt in

[1] Zur Kenntniss des Polymorphismus der Ameisen. Zool. Jahrb. Suppl., VII, 1904, pp. 587–610, 9 figs.

[2] Ameisenarbeiterinnen als Ersatzköniginnen. Mittheil. d. schweiz. entomol. Ges., XI, 2, 1904, p. 67.

[3] Die ergatagynen Formen bei den Ameisen und ihre Erklärung. Biol. Centralbl., V, 1895, p. 606.

the anterior region, and especially in the head, while the abdomen is unduly expanded by the worm. Since the thorax of the normal worker, as a portion of the body already reduced to a minimum, is incapable of further diminution, it remains unchanged. In the head, however, the results of imperfect nutrition are more strongly felt; there is no longer sufficient substance to form the powerful muscles that go to move the mandibles, so they remain small, and with them the muscle-containing occipital portions of the head are unable to acquire their normal proportions. Hence the characteristic narrowing in the posterior region of the head.

"The explanation of the appearance of the ocelli and the greater development of the eyes in the parasitized microcephalæ seems to me to present more serious difficulties. It might be supposed that, owing to the small development of the occipital region of the cranium, a greater quantity of ectodermal substance had remained over and thereby established more favorable conditions of space and nutriment for the formation of the eyes and ocelli. Unfortunately, the preservation of the dry specimens did not permit an accurate anatomical study of the organs contained in the cranium. I feel certain, nevertheless, that we are here dealing with something like a general law.

"The effect of the parasite on the formation of the body, and especially of the head, is not always equally intense: the extent of this effect depends on the relations of the size of the worm to that of the ant. The larger the worm, and hence the greater the volume of the abdomen of the ant, the greater the aberration in the head. For this reason *Pheidole* shows the greatest alteration, then come the two species of *Odontomachus* and *Pachycondyla fuscoatra*, then *Neoponera inversa*, and finally *Paraponera*; in this gigantic ant the increase in the abdomen had no appreciable influence on the shape of the head."

This adaptation of Roux's 'Kampf der Teile in Organismus' to the mermithergates seems very plausible at first sight, but on closer examination it proves to be less satisfactory as an explanation of the phenomena. It would seem to be necessary to reach some definite conclusion, first, as to the morphological relations of the mermithergates to the normal castes of the species, and, second, as to which parts of the mermithergates are enlarged at the expense of other parts. In the case of *Pheidole* there are three possible answers to the first question: the mermithergates may represent small-headed, *i. e.*, defective soldiers; second, they may be very defective females, and third they may represent excess development of the worker caste. Emery rejects the third possibility, and while considering the two others, is inclined to regard the mermithergates as having arisen from soldier larvæ in which the gaster has appropriated the nutriment of the head region so

that the latter is greatly reduced in size. This interpretation, which derives its plausibility from the soldier-like structure of the thorax in the parasitized *Pheidole absurda,* is equally applicable to *Ph. commutata.* Emery is, however, unable to account satisfactorily for the appearance of the ocelli and larger eyes. The case of *Pheidole* is certainly complicated by the existence of a soldier caste. Both in the Ponerine ants studied by Emery (*Odontomachus, Neoponera, Paraponera,* etc.), and in the species of the Myrmicine *Cremastogaster* above described, this caste does not exist, and hence the mermithergates may be only excess developments of the worker, or defective developments of the female. Although in these cases I believe that the former alternative is the more probable, at least in some of the species, the question can hardly be settled without much additional material.

Emery takes it for granted that the gaster is an excess development, because it is so greatly enlarged in the adult mermithergates. But I have shown that in the pupæ in *Ph. commutata,* at least, the gaster is proportionally no more developed than any other part of the body. Hence we cannot conclude that the head is small because the gaster is large. We must rather suppose that the whole body exhibits excessive and uniform growth, and this must, of course, mean a uniform distribution of the metabolized nutriment in the larva.[1] It would seem, therefore, that the mermithergates, if they really arise from soldier larvæ, retain small heads because the parasites and not the abdominal tissues appropriate the substances which in the normal soldier go to form the cephalic region. This is indicated by the fact that the head of the soldier does not develop till the semi-pupal stage, when the pellucid cephalic substances may be seen rapidly accumulating in the previously slender anterior region. This explanation, which resolves itself into a very obvious struggle between the larva and its parasite and not between the parts of the larva, will also account for the smaller heads in the Ponerine mermithergates. In all cases the pupa tends to become a well-proportioned whole. It is evident that this tendency is very different from an unequal struggle of the various body regions with one another, since it implies a uniform distribution of the available nutriment. It implies, moreover, defect developments in the head, in the case of the soldier larvæ. The failure to develop the huge head of the soldiers in *Pheidole* mermithergates is in all probability due to the suppression of a very recently acquired character by the parasite, since there is every reason to suppose that the soldier caste among these and other ants is of much less phylogenetic antiquity than the worker. This seems to be clearly indicated in the ontogene-

[1] Dr. T. H. Montgomery informs me that crickets (*Gryllus abbreviatus*) infested with *Mermis* or with *Paragordius varius* are apt to be larger than uninfested individuals. The enlargement is not confined to the abdomen but also affects the other regions of the body as in mermithergates.

tic development of colonies of *Pheidole, Camponotus,* etc., for in these only small-headed workers are at first produced by the queens. Here scarcity of food produces almost the same results as parasitism — namely microcephaly. At the same time that the tendency to produce a well-proportioned pupa suppresses the recently acquired macrocephalic characters of the species, it may be conceived to encourage the development of certain ancient phylogenetic characters like the ocelli and larger eyes. This is especially the case in the *Pheidole* larva for two reasons: first, because the mermithergates of these ants probably approach more nearly the ancestral stature of the workers, since it is very probable that the *Pheidole* workers have undergone a reduction in size during the phylogeny of the genus, and second, because the larva, notwithstanding its parasites, nevertheless succeeds in accumulating more formative substance than is necessary for the production of a normal worker.[1]

On the basis of the above interpretation, which I would substitute for Professor Emery's, an interesting comparison may be instituted between the mermithergates of *Pheidole commutata* and *absurda* on the one hand, and the phthisergates of *Ph. instabilis* on the other. In the former cases the parasitic *Mermis*, situated in the abdomen of the larval ant, appropriates to its own growth the substances that will later be required to increase the volume of the pupal and imaginal head. In the latter case, the ectoparasitic *Orasema* larva, situated just behind the head of the semipupal ant, intercepts and extracts the head-producing substances as they flow forward from the abdominal region into the anterior end of the body. In both cases the result is a pathological microcephaly, extreme and peculiar in the moribund pupal phthisergates of *Ph. instabilis*, much less pronounced but persisting into the imaginal stage in the less seriously parasitized *Ph. absurda* and *commutata*.

Emery has called attention to the interesting fact that all the known mermithergates occur among American ants. They occur moreover in species peculiar to the tropical or subtropical portions of the New World. This would seem to indicate that the single or several species of *Mermis* which produce this anomaly in ants are of rather circumscribed distribution. The genus *Mermis*, however, seems to be cosmopolitan, judging from von Linstow's recent revision of the group (*l. c.*). He records species from Europe, Turkestan, Madagascar, Southwest Africa, New Zealand, United States, Costa Rica, and Brazil. Some of the species, like the European *M.*

[1] The effects of the parasitic *Mermis* on the host are not confined to mere mechanical distortion and the withdrawal of nutriment. There is much evidence to show that both Nematodes and Cestodes secrete toxic substances that have a positive and far reaching effect on the tissues of their hosts. In this connection see: von Fürth, Vergleichende Chemische Physiologie der Niederen Tiere, Jena, 1903, pp. 308–310, and Faust, Die Tierischen Gifte, Braunschweig, 1906, pp. 223–228.

albicans von Siebold and *nigrescens* Duj., are well known parasites in several insect hosts, although no ants are recorded among the number.

3. The Parasitism of the Lomechusini.

Our knowledge of the extraordinary myrmecophilous beetles of the Staphylinid tribe Lomechusini is largely due to the indefatigable researches of the Jesuit Father E. Wasmann. Beginning in 1886 and continuing to the present time, these researches comprise a series of more than thirty papers.[1] The work has been taken up more recently by Viehmeyer in Germany and by Father Muckermann in Wisconsin. My own observations, which are still very fragmentary but not without interest, will be recorded after reviewing the work of the authors just mentioned.

A. The European Lomechusa and Atemeles.

The ethology of the Lomechusini is succinctly summarized by Wasmann in the following paragraphs:[2]

"The *Lomechusa* group, embracing the palearctic genera *Lomechusa* and *Atemeles* and the nearctic genus *Xenodusa*, contains, from an ethological point of view, the most interesting and at the same time the largest of the true ant-guests (symphiles) of the arctic region. These Staphylinids, which belong to the subfamily Aleocharinæ, are treated by the ants like their own kith and kin, live in antennary communication with them, are cleaned and licked and occasionally also carried about; they are fed from the mouths of their hosts, although they are also able to eat independently and frequently devour the ant-brood. The ants are especially attracted to these beetles on account of the prominent tufts of yellow hairs on the sides of their abdomen which are licked by the host with evident satisfaction. Not only do these beetles themselves live as guests among the ants, but the same is also true of their larvæ. The larvæ of *Lomechusa* and *Atemeles* are reared by the ants like their own brood; they are licked, fed with regurgitated food and, before pupation, covered or embedded in cells like their own larvæ. When the nest is disturbed they are carried by the ants to a place of safety in preference to their own larvæ and pupæ. The predelection of the ants for these adopted larvæ is all the more remarkable because they are the worst enemies of the ant-brood and consume enormous numbers of the eggs and larvæ of their hosts. This brood parasitism, in fact, causes the development of abortive individuals intermediate between the female and worker castes, and these

[1] Twenty-five of these papers, down to 1902, are cited by Wasmann himself at the end of a twenty-sixth contribution entitled: Neue Bestätigungen der Lomechusa-Pseudogynen-Theorie. Verhandl, deutsch. Zool. Ges., 1902, pp. 107–108; the remaining bibliography may be found among the cards of the Concilium Bibliographicum.

[2] Zur Biologie und Morphologie der Lomechusa-Gruppe. Zool. Anzeig., No. 546, 1897, pp. 463–465.

intermediates, which I have called pseudogynes, gradually bring about a degeneration of the parasitized colonies.

"Within the *Lomechusa* group an important ethological difference obtains between *Lomechusa* and *Atemeles*, inasmuch as the former is homœcious, *i. e.*, the species of this genus have each but a single host (a species of *Formica*), in whose company they complete their whole life-cycle; whereas the *Atemeles* are heterœcious, since as adult beetles they live with *Myrmica rubra* and a species of *Formica*, but have their larvæ reared only by the latter. The fact that *Lomechusa* has only a single host explains the more highly developed *passive* stage of its symphily. This is evident from the one fact among others that the beetle is more affectionately treated by its normal hosts and is fed, not like an ant, but more like an ant-larva. The heterœcious character of the *Atemeles*, which are compelled twice during their life time to change their normal hosts, once in the spring when they migrate for reproductive purposes from *Myrmica* to *Formica*, to have their larva reared by the latter, and once in the summer or autumn, when they migrate from *Formica* to *Myrmica* for the purpose of hibernating, enables us to explain the greater *active* perfection of their symphily, their greater initiative towards the ants, and the closer imitation of their behavior. The last peculiarity is especially apparent in that they do not, like *Lomechusa*, *Claviger*, and *Amphotis*, beg the ants for food merely by stroking them with their antennæ, but also raise their fore-feet after the manner of ants, and stroke the cheeks of the regurgitating hosts. On this account they are treated by their normal hosts like ants and not like ant-larvæ."

Five species of *Lomechusa* and a greater number of species and varieties of *Atemeles* have been described. Of these *L. strumosa* is the best known. It is exceedingly rare in England,[1] but appears to be more abundant in certain parts of the continent, especially in Holland and Luxemburg, where Wasmann has been carrying on his investigations. Its normal host is the blood-red slave-maker (*Formica sanguinea*), though very rarely it may be found in the nests of *F. rufa* and *pratensis*.

In the present article we are mainly concerned with the pseudogynes mentioned in the above quotation. Wasmann has subjected these individuals, which were well known to Forel[2] and Adlerz,[3] to a searching examination, and describes them as follows:[4]

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[1] According to Donisthorpe (Record of Capture of Lomechusa at Woking with Formica sanguinea. Entomologist, XXXIX, July, 1906, p. 163), only three specimens have been recorded from England. Besides the one referred to in his article, one was "taken by Sir Hans Sloane on Hampstead Heath in 1710, the other found by Dr. Leach in the mail-coach between Gloucester and Cheltenham."

[2] Les Fourmis de la Suisse. Zürich, 1874, p. 138.

[3] Myrmecologiska Studier. II Svenska Myror och deras Lefnadsförhållanden, Bihang. Svenska Vet. Akad. Handl., XI, No. 18, 1886, p. 76.

[4] Die ergatogynen Formen bei den Ameisen, *l. c.*, p. 612.

"Morphologically these pseudogynic workers may be characterized as an abortive combination of the thoracic structure of the female with the stature and gastric development of the worker; they impress one as frustrate workers, that have borrowed a female thorax. Their size, according to my observations, which extend over materials from a great number of colonies, is rarely greater than that of the average normal workers of the same colony, often considerably less. The head and gaster are small, the former, in its relatively small dimensions, more like that of the female than the worker. The ovaries are, if anything, more feebly developed than in the ordinary workers. The mesonotum is hunched, disproportionately large compared with the pro- and epinotum, and is usually relatively higher than in the female. In many specimens the scutellum is large and separated off by a transverse suture from the mesonotum. The postscutellum [metanotum], on the contrary, is barely indicated, although in some individuals it forms a distinct narrow strip, while the scutellum is not separated off in front, but instead divided into two halves by a longitudinal line which is lacking in the female." Wasmann has found the pseudogynes most frequently in the nests of *F. sanguinea,* more rarely with *F. rufa, pratensis* and *fusca.* When they occur they often make up from 5–7% of the personnel of the colony, more rarely as much as 20%. "The coloration of the pseudogynic workers is almost without exception paler than that of the normal workers. This is especially true of the thorax; the color of the head, however, is often darker than in the normal workers of the same colony, and corresponds to the darker head of the female. The slight color variation in the pseudogynic *sanguinea* is explained by the fact that in this species the female and worker are very similarly colored. Conditions are different in *F. rufa* and *pratensis.* Here the color of the pseudogyne, although generally more like the darker tint of the female, is much more variable. In some fully mature individuals it is paler than in the palest workers of the same colony. . . . All pseudogynes are, as Forel observed, cowardly and indolent. Not one of them attempted to bite me while I was plundering their nests, though I often knelt near them for hours while sifting out the myrmecophiles. The very opposite was true of the normal workers, which defended themselves with fury. The pseudogynes act as if they regarded themselves as frustrate existences. In several of the observation nests of *F. sanguniea* kept in my room, they neither took part in excavating the earth nor in nursing the brood; they did more running about, however, than the females. Their vitality seems to be feebler than that of the normal workers, for none of them managed to survive a captivity of several months, although some were callows and the remainder of the colony was in a prosperous condition."

Transitions between the pseudogynes and the normal workers on the

one hand, and normal females on the other, are of very rare occurrence. Wasmann [1] has, however, seen one colony in which "all possible transitions between normal workers and females were represented. The pseudogynes of this colony may be divided according to their stature into micropseudogynes, mesopseudogynes and macropseudogynes. Among the mesopseudogynes there are numerous transitions to the workers, but never with vestiges of wings; among the macropseudogynes there are ergatoid and gynæcoid forms, of which the former sometimes bear distinct vestiges of wings on the relatively short, narrow mesothorax, while the latter often possess perfectly developed but rather short wings on the exceedingly broad mesothorax, and in addition similar posterior wings on the metathorax. The latter forms may be designated as macronotal, brachypterous females, in contradistinction to the normal stenonotal, macropterous females."

As Wasmann's researches progressed he became more and more impressed with the fact that the parasitism of the Lomechusini and the occurrence of the pseudogynes stood in a causal relation to each other. A five years' statistical study of 410 colonies of *Formica sanguinea* near Exäten in Holland finally led him to maintain the following theses: [2]

"a. The regions in which pseudogynes occur always coincide with *Lomechusa* regions.

"b. The colonies containing pseudogynes are always the centers of *Lomechusa* regions.

"c. Pseudogynes are never found in *sanguinea* colonies outside the *Lomechusa* regions.

"d. In colonies in which *Lomechusa* lives merely as a beetle (*i. e.*, in the imaginal instar), pseudogynes are never developed, but only in such as have for years been rearing the larvæ of *Lomechusa*."

These results were found to hold good also for other European localities. He found, moreover, a similar causal connection between the occurrence of pseudogynes of *F. rufa* and the beetle *Atemeles pubicollis*, *F. rufibarbis* and *A. paradoxus*, *F. fusca* and *A. emarginatus*. In the case of *Atemeles*, of course, the pseudogynes are restricted to the ants among which its larvæ are reared and do not occur in the *Myrmica* colonies with which it merely hibernates. The *Formica* colony is therefore analogous to the definitive host of diœcious, non-social parasites like the tapeworm, while the *Myrmica* colony corresponds to the temporary host of this entozoon.

As early as 1895 [3] Wasmann undertook to explain the origin of the

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[1] Ueber ergatoide Weibchen und Pseudogynen bei Ameisen. Zool. Anzeig., No. 536, 1897, p. 252.

[2] Neue Bestätigungen der Lomechusa-Pseudogynen-Theorie. Verhandl. deutsch. Zool. Gesell., 1902, p. 100.

[3] Die ergatogynen Formen, etc., *loc. cit.*

pseudogynes. Previous authors had been inclined to regard them as cases of atavism, *i. e.*, as reversions to the primitive female form (Adlerz) or as blastogenic anomalies, *i. e.*, as due to some peculiarity in the structure of the egg and hence referable to hereditary factors (Weismann, Forel). Wasmann, however, took the view that they "are probably due to a post-embryonic sistence in the development of the typical female form, and arise from larvæ which were originally destined to become females, but had already passed the stage of wing-formation and had then been converted into workers." He conceives this deflection in the normal development to take place in the following manner:[1]

"The normal mating period of *Lomechusa strumosa,* according to my observations, is from the middle of May to the middle of June. Usually the *Lomechusa* larvæ are to be found in the *sanguinea* nests only after this period. At the very time when the *Lomechusæ* begin to lay their eggs, *sanguinea* begins to lay a number of fertilized eggs which are to produce workers. Both among these and the young larvæ of the worker generation the *Lomechusa* larvæ, as I have observed, make terrific havoc. I have noticed that their food often consists almost exclusively of these eggs and young larvæ, and that in the course of a few days a single *Lomechusa* larva can devour a great number of them. I have seen some of the larger *Lomechusa* larvæ attack and devour several ant larvæ 4–5 mm. in length, one after another, although the *Lomechusa* larvæ in this stage are usually fed from the mouths of the ants. As there may be as many as several dozen *Lomechusa* larvæ in a single nest, the greater portion of the first annual worker generation may be destroyed in the course of a few weeks, for the parasites are extremely voracious and grow on the average almost a millimeter in length a day, and attain their definitive development (11 mm.) from the egg to the adult larva (and that at rather low temperatures in my observation nests) in 12 to 13 days. Hence there must arise a very perceptible and sudden falling off in the development of the worker generation and the ants endeavor to make good this deficiency by converting into workers all the available larvæ of the immediately preceding generation, that were originally destined to become females.

"Another factor, secondary in importance, however, compared with those above mentioned, confirms the tendency of the ants to transmute the female larvæ into workers, namely the extraordinarily rapid growth of the *Lomechusa* larvæ. On this account the workers lavish the care, which would otherwise be devoted to the female larvæ, on the *Lomechusæ* instead, for these impress the ants as being most admirable offspring. This in turn

[1] Die ergatogynen Formen, etc., *loco cit.* p. 632.

leads to a neglect of the female larvæ. (It is the counterpart of the rearing of the young cuckoo in the nest of the white-throat!) As a matter of fact, the *Lomechusa* larvæ are the first to be rescued when the nest is disturbed. In general it may be said (according to my observations, in part previously published) that whenever I placed *Lomechusæ* in strange *sanguinea* nests, the presence of the beetles themselves often led to a neglect of the brood, and more especially of the large female larvæ."

It will be observed that Wasmann's view, which he styles a theory, rests on several inferences of very different degrees of probability. He may be said to have demonstrated that pseudogynes result from the parasitism of *Lomechusa* and *Atemeles* on various species of *Formica*. His further contention that the pseudogynes are not of blastogenic origin but arise from normal female larvæ that have developed under abnormal conditions, must also be granted; especially as it has recently received experimental confirmation from Viehmeyer.[1] This investigator removed an aged *sanguinea* queen from her colony which had for some years been producing pseudogynes, owing to the presence of *Lomechusa* larvæ, and caused her to be adopted by a new set of fifty unusually fine workers from an uninfested colony. Her eggs under the changed conditions developed into larvæ that gave rise to normal workers. This, of course, proves that the pathogenic conditions cannot have their origin in the queen or in her ova. Wasmann has since published a similar experiment.[2] Two *sanguinea* females belonging to a colony from Exäten and containing many pseudogynes were given slaves (*F. rufibarbis*) from Luxemburg colonies that had never been infested with *Lomechusa* and *Atemeles*. During four consecutive years the offspring of these females developed only into normal workers.

Up to this point Wasmann's hypothesis seems to rest on firm foundations, but as much cannot be said of his explanation of the pseudogynes as the abortive results of a belated attempt on the part of the workers to transmute female larvæ into workers. He here steps on debatable grounds. It seems to me that he has come nearer the truth in that portion of the quotation above cited where he calls attention to the neglect of the female larvæ by their nurses, for it is natural to suppose that these neglected larvæ would be able to pupate and produce pseudogynes without any active intervention on the part of the workers such as the administration of a particular kind or quantity of nourishment. The great variation in stature among normal *Formica* workers on the one hand, and among females on the other, shows that there must be wide limits of larval stature within which spontaneous pupation

[1] Experimente zu Wasmann's Lomechusa-Pseudogynen-Theorie. Allgem. Zeitschr. f. Entom., IX, 1904, pp. 334–344.
[2] Ameisenarbeiterinnen als Ersatzköniginnen, etc., *loc. cit.* p. 69.

is easily possible; and there is no occasion to suppose that this may not occur among larvæ intermediate in size between those of the workers and females. The only apparent objection to this view is one which undoubtedly occurred to Wasmann himself and led him to suppose that the nurses actively transmute the female larvæ into workers, namely, the fact that the stature of the pseudogynes is usually below, and often considerably below, that of the largest workers. This, however, may be due to purely physiological causes resident in the larvæ themselves, for these would suffer starvation as a result of the ants' infatuation with the *Lomechusa* larvæ and hence lose much of their substance (water and fat) by oxygenation during the period previous to pupation and subsequent to the inhibited histogenetic changes that have already progressed beyond the worker stage. Under these circumstances pupation would wear the aspect of a regenerative or regulatory process analogous to that which leads the isolated blastomeres of the sea-urchin and other animal ova to develop into complete but more or less abortive and diminutive larvæ.

The chief advantage of such an explanation lies in the elimination of an appeal to special instincts such as would be implied by an endeavor on the part of the worker ants to restore one portion of the colony — the vanishing worker personnel, at the expense of another portion — the annual supply of virgin females. Such an endeavor, though itself of the nature of a colonial regeneration or regulation, is not improbable, but on the principle of *entia non sunt multiplicanda præter necessitatem,* does not seem to be necessary to an explanation of the phenomena. On general biological principles we should expect moribund ant colonies to take the opposite course and hasten the development of the sexual forms as the most appropriate method of insuring the survival of the species and thereby the production or rejuvenation of colonies. The explanation above suggested has, moreover, the advantage of being applicable to other cases besides the pseudogynes of *Formica.* While treating of *Pheidole instabilis* (p. 3) I called attention to the occurrence in that ant and in a few allied species belonging to the Sonoran province, of a series of intermediates, or *desmergates,* as they may be called, connecting the typical worker (*ergate*) and soldier (*dinergate*) castes. As these desmergates are perfectly normal I could not regard them as the result of *Orasema* parasitism like the phthisergates, phthisogynes, and phthisanērs. Moreover, similar intermediates are of regular occurrence in species of several other genera (*Eciton, Dorylus, Solenopsis, Azteca, Camponotus,* etc.) where parasitism as an explanation is out of the question. In all of these cases the desmergates probably arise from larvæ that have been neglected by the ants after having been enabled to grow and develop beyond the typical worker stage. That such neglect

should often occur is not surprising when we stop to consider that much of the time and energy of the workers of an ant community are consumed in other duties besides feeding the brood, such as foraging, excavating, cleaning one another, etc. Then, too, the rate of reproduction is enormous and must often out-run the available food supply, which itself is by no means constant. The very slow development of ants in their larval stages is evidence of slow metabolism, and as this cannot be due to low temperatures, at least during the summer months, we must suppose that long periods of enforced fasting or positive starvation not infrequently intervene in the lives of larval ants. Still further conditions which may, perhaps, conduce to the same result may be found in the apparent absence of a very definite and well organized system of feeding the enormous brood, and the fact that this important function is frequently entrusted to the presumably more or less inexperienced callows.

B. The North American Xenodusa.

The Lomechusini are represented in North America by the single genus *Xenodusa*. Our best known species is *X. cava* Leconte (Pl. III, Fig. 41), a deep red beetle, 5–6 mm. in length, with slender legs and antennæ and tufts of golden hairs (trichomes) on the abdomen, which is concave above, like the thorax, and turned up at the tip. This species, which is so closely allied to the European forms that it has been placed successively in the genera *Atemeles* and *Lomechusa*, is stated by Wasmann to be "ziemlich häufig" in the United States, but it has certainly proved to be decidedly rare in my own experience and that of several coleopterists of my acquaintance. Messrs. W. Beutenmüller and C. Schäffer, who have given much attention to our beetles, tell me that they have never taken it, and there is only a single poorly preserved specimen in the large collection of the American Museum. There may, of course, be localities in which the insect is as common as *Lomechusa strumosa* in continental Europe, but if such exist, they have not yet been discovered or divulged.

Leconte, who in 1865 first described *X. cava* under the name of *Atemeles cavus*, stated that he had never taken the insect and did not know its host.[1] Some years later, according to McCook,[2] he succeeded in taking it in the mounds of *Formica exsectoides* in the Alleghenies of Pennsylvania and in the nests of *F. rufa* (?) in various localities. This latter datum, however, is negligible, since the species of the *exsecta* and *rufa* groups in this country had not at that time been clearly differentiated.

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[1] New Species of North American Coleoptera. I. Smiths. Miscell. Coll., No. 167, 1863, p. 30.

[2] Mound-making Ants of the Alleghenies, their Architecture and Habits. Trans. Am. Ent. Soc., VI, 1877, pp. 253–296, pl. i–vi.

Blanchard in 1879,[1] described in a brief note the capture of some 50 specimens of *X. cava* in a large colony of black ants, which could only be *Camponotus herculeanus pennsylvanicus* De G., in a white oak near Tyngsboro, Massachusetts. The word "recently" occurring in this note, which was dated May 1, shows that the *Xenodusæ* must have been taken during the winter or early spring and that they were hibernating with the *Camponotus*. Hamilton, who published a good list of American myrmecophilous beetles in 1888,[2] had apparently never taken *Xenodusa*, as he cites only the records of Leconte and Blanchard. Schwarz, in 1890,[3] mentions the insect as occurring with *C. pennsylvanicus* and *C. ligniperdus* var. *novæboracensis* (=*pictus* Forel) on his own authority and that of Leconte, Pergande, and Hubbard. Wickham,[4] also records it as occurring with *C. novæboracensis* at Iowa City, Iowa.

In a recent paper Muckermann,[5] has inaugurated a slight advance in our knowledge of the habits of *Xenodusa*. Aug. 23, 1900, he succeeded in finding it in the vicinity of Prairie du Chien, Wisconsin, in a nest of *novæboracensis*, and during October of the following year he found within a hundred feet of this nest a colony of *Formica sanguinea rubicunda* containing a number of pseudogynes. The circumstances indicated a causal connection between the occurrence of the pseudogynes and the parasites very similar to the connection established in Europe by Wasmann for the heterœcious *Atemeles*. It must be expressly stated, however, that Muckermann did not find *Xenodusæ*, either as adults or larvæ, in the *rubicunda* nest. And to my knowledge no one has yet taken the beetle in colonies of any of the American forms of *sanguinea*.

Up to the present time I have been able to find *X. cava* only in two localities: Rockford, Illinois and Colebrook, Connecticut. These are, to be sure, the very localities in which I have collected ants most carefully. The following is the only observation made at Rockford: August 5, 1902, I took two fine specimens of *X. cava* from a large and flourishing colony of *C. novæboracensis* in an old log completely riddled with the galleries of the ants. Neither *Xenodusa* larvæ nor pseudogynes were seen. The nest was well stocked with *Camponotus* larvæ and pupæ in all stages and also contained several fine winged females. There were many *rubicunda* nests in the immediate vicinity but no pseudogynes were to be found among their inhabitants.

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[1] Bull. Brooklyn Ent. Soc., II, 1879, p. 4.

[2] Catalogue of the Myrmecophilous Coleoptera, with Bibliography and Notes. Canad. Entom., XX, 1888, No. 5, p. 164.

[3] Myrmecophilous Coleoptera Found in Temperate North America. Ent. Soc. Wash., I, No. 4, 1890, p. 243.

[4] Further Notes on Coleoptera found with Ants. Psyche, VII, 1894, p. 80.

[5] *Formica sanguinea* subsp. *rubicunda* Em. and *Xenodusa cava* Lec. Ent. News, Dec. 1904, pp. 339–341, pl. xx.

My observations in Colebrook were more extensive and were all made on nests occurring on the slopes of three adjacent hills, which, for present purposes, may be designated as the eastern, middle and western hill, covering a strip of territory about a mile and a half long and a quarter of a mile wide, or less than half a square mile. Late in August, 1900, I found a few *Xenodusæ* in two large *novæboracensis* colonies on the middle hill. These colonies were essentially like the one seen at Rockford, except that neither contained winged females. My remaining observations relate to a very different ant, *Formica schaufussi* var. *incerta* Emery, which forms many colonies on the Colebrook hills. This ant, as I have shown in former articles,[1] is the normal temporary host of *F. difficilis* var. *consocians* Wheeler. The following observations show that it is also the host of *X. cava*. I may mention incidentally that, although *F. rubicunda* and its var. *subintegra* are very common in the same territory, I have never been able to find the beetle in any of their nests.

F. incerta first impressed me as being a probable host of *Xenodusa* in 1904, when I began to notice pseudogynes in a number of the colonies. August 13 to 24 of that year I took pseudogynes from seven colonies on the eastern and middle hills. Five of these colonies each contained only a few of the abnormal insects, but two, which seemed to be incipient colonies, contained unusually small, pale workers together with numerous pseudogynes of the same dimensions. One of the latter colonies, taken August 25 also contained a diminutive but perfectly developed female (microgyne). This colony was kept in an artificial nest till September 16. The numerous pseudogynes behaved in all respects like normal workers. They fed one another, carried the cocoons away when the nest was illumined, etc. In another colony that was used for some experiments with *F. consocians*, two pseudogynes, which had hatched late in August, 1904, lived till April 9 of the following year, and this notwithstanding the fact that one of them had much crippled antennæ and had to be fed and cared for by the normal workers during the whole period.

A remarkable colony was found during the early morning of August 13. The preceding night had been unusually cold so that the ants were still very inactive and I was able to capture the entire personnel. It consisted of the following: a single deälated female, to all appearances the mother of the colony; 8 perfectly normal winged females; 46 normal workers; 2 larvæ; 193 pseudogynes, and 12 pseudogyne pupæ. In this colony, therefore, nearly 80% of the personnel were pseudogynes! In size these averaged like

[1] A New Type of Social Parasitism among Ants. Bull. Am. Mus. Nat. Hist. XX, 1904, pp. 347–375; and On the Founding of Colonies by Queen Ants, with Special Reference to the Parasitic and Slave-making Species. *Ibid.*, XXII, 1906, pp. 33–105.

the workers, and were of the same color, except that a number of them had traces of the black antero-median and parapsidal blotches of the female on the mesonotum. They had a perfectly normal appearance, as the enlargement of the mesonotum led to less distortion and inelegance of profile than in pseudogynic *F. sanguinea* and *rufa*, since in *incerta*, which belongs to the *pallide-fulva* group, the thorax, even of the normal worker, is unusually long. Traces of the scutellum and metanotum were rarely present in any of the specimens, so that the only difference between these and normal workers was the greater prominence of the mesonotum. The extent of this modification may be clearly seen by comparing Plate III, Fig. 42, which represents a large typical worker, and Figs. 43 and 44, which represent pseudogynes from the same colony and drawn under the same magnification.

On finding these pseudogynes I was convinced that an examination of the *incerta* nests earlier in the season would reveal the presence of *Xenodusa*. Accordingly, on revisiting Colebrook during July of the following year (1905) I set to work to look for the beetle and its larva. July 1, I found under a stone on the middle hill a small colony of *incerta* containing about 75 normal workers, a few worker pupæ and larvæ, and 6 larvæ which, from their resemblance to Wasmann's figure of the *Lomechusa* larva[1] could at once be recognized as those of *X. cava*. The legs, however, seemed to be much longer and the body more slender and more concave above. They were clinging to the lower surface of the stone covering the nest. I transferred them to an artificial nest together with as many of the ants as I could capture. The larvæ associated themselves with the brood which the ants had collected in the cavities of the damp sponge in the dark chamber of the nest. They walked about but little and very clumsily as their legs seemed to be incapable of much movement at the strongly flexed articulation between the femora and tibiæ. They were frequently seen in the act of begging the ants and one another for food. At such times they raised their fore feet and stroked the head of the ant or fellow larva. Although the ants usually responded very willingly to this solicitation, the liquid food thus received seemed to be insufficient, for one morning I saw one of the *Xenodusa* larvæ seize and devour an ant larva about 3 mm. in length. On July 7 two of the *Xenodusa* larvæ had disappeared (eaten by the ants?) and the remaining four had become somewhat inactive after having grown appreciably during their week's confinement in the artificial nest. Fearing that the ants might devour the remaining parasites, and concluding from their size that they must be nearly ready to pupate, I removed them from the nest and embedded them in some earth. This proved to be disastrous as I had not taken the precau-

[1] Die Moderne Biologie und die Entwicklungstheorie. 2 Aufl., Freiburg i. Br., 1904, p. 223, fig. 30.

tion to sterilize the earth which must have contained some predacious insect. At any rate, I could find no traces of the larvæ when I carefully examined the earth several days later.

This brief but interesting glimpse of the larval life of *Xenodusa* led me to examine all the *incerta* nests I could find in the hope of obtaining more of the parasites. Although I failed to secure any more of the larvæ, I was rewarded July 14 by finding a mature *Xenodusa* in a small colony on the western hill. This colony had a depauperate appearance and comprised only about 50 workers, two deälated females and a few worker pupæ. It contained no pseudogynes.

These observations, made, as I have stated, within an area of less than a square mile, prove that the larvæ of *X. cava* are reared by *F. incerta* during the latter part of June and the first weeks of July, and that the adult beetle may be found as early as the middle of the latter month. During August, however, the *Xenodusæ* are found only with *C. novæboracensis*. That they pass the winter with ants of this species is indicated by Blanchard's note cited above. It is probable therefore that *X. cava* is heterœcious like the European *Atemeles*, as Wasmann surmised,[1] but instead of a Myrmicine and a Camponotine host, both hosts in the American species are Camponotine ants.

The occurrence of pseudogynes late in the autumn in so many of the *incerta* nests agrees well with Wasmann's theory that these anomalous forms are the result of Lomechusine parasitism, but there are several facts connected with this occurrence which seem not to be in full accord with his theory. A colony like the one above described, which contained nearly 80% of pseudogynes together with several normal winged females, was not encountered by Wasmann in his study of the *sanguinea* colonies. He never found more than 20% and usually the number did not exceed 5%. He says, moreover:[2]

"According to this theory the pseudogynes arise from converted female larvæ; from which follows, first, one ought to find no recently hatched normal females, or at least very few of them, in the same colony with recently developed pseudogynes, since the female larvæ of the respective generation have been changed into workers as far as possible; second, the number of pseudogynes in a single colony must not surpass the number of normal females which they represent. I do not hesitate to subscribe to both of these conclusions. The former, at least according to my own observations, is actually substantiated, since I cannot remember ever to have found recently developed females associated with recently developed pseudogynes. At

[1] Zur Biologie der Lomechusa-Gruppe. Deutsche ent. Zeitschr., 1897, Heft II, p. 275.
[2] Die Ergatogynen Formen, *loc. cit.*, p. 635.

first sight the second conclusion seems not to be justifiable. For how is it to be reconciled with the occurrence of as many as 20% of pseudogynes in a single nest? We must not, however, lose sight of the fact that the usual percentage of pseudogynes does not surpass that of the winged females, which may occur in a colony of *Formica sanguinea* or *rufa*, and that it certainly does not surpass the maximum which, according to my observations, may reach 5% in many *sanguinea* colonies. Now the pseudogynes do not leave the nest but remain in it, whereas the normal females escape at the time of the nuptial flight; hence it is only necessary that the conversion of larvæ into pseudogynes should be repeated for several generations and several years, to raise the number of these individuals to 20%." Wasmann also states that it is nearly always the same *Formica* colonies that are found to contain *Lomechusa* and *Atemeles* year after year. These considerations, however, fail to throw any light on the above described colony of *F. incerta* with its enormous number of pseudogynes associated with winged females and so small a number of workers. For if *X. cava* hibernates with *C. novæboracensis* it does not seem probable that it would return year after year to the same *incerta* nest, when there are hundreds of nests of this ant in the immediate neighborhood. Then, too, *incerta* colonies, unlike those of *sanguinea*, *rufa*, and *fusca* are very small, rarely comprising more than about 500 individuals, and could not even survive to raise *X. cava* year after year if the larvæ of this beetle are as destructive to the brood as the larvæ of *Lomechusa* and *Atemeles*. But this wholesale destruction would seem to be necessary, according to Wasmann's view, to bring about the conversion of female larvæ into pseudogynes. Moreover, if the pseudogynes are as short-lived as Wasmann supposes, how can they accumulate to any great extent in a single colony? And finally, how can a colony of *incerta* of the size of the one above described produce as many as 213 females in a single season? These considerations lend probability to the view that Wasmann's theory may require some emendation when we come to have a fuller knowledge of the habits of *Xenodusa*.

F. incerta and *rubicunda* are not the only North American ants that are able to produce pseudogynes. In going over my collection I find that I have mounted a number of these anomalous individuals with the normal workers from nests of the following ants:

1. *F. rufa integra* Nyl.

(a) A single pseudogyne taken several years ago by Mr. J. Angus at West Farms, now a part of New York City.

(b) A couple of callow pseudogynes collected July 8, at West Chester, Pennsylvania, by Mr. J. C. Bradley.

(c) Five pseudogynes which hatched in an artificial nest from cocoons taken August 1, 1905, from a very large colony at Colebrook, Connecticut. None of these is larger than a small or medium-sized worker of *integra*, but they all have the thorax clouded with black, although this subspecies differs from other forms of *rufa* in the absence of any infuscation of the head and thorax even in the smallest workers.

2. *F. rufa obscuriventris* Mayr. var. *melanotica* Emery.

During August, 1903, a number of cocoons of this ant were taken from a large and flourishing colony at Rockford, Illinois, and placed in an artificial nest containing *Polyergus rufescens breviceps* Emery with *F. cinerea* var. *neocinerea* Wheeler as slaves. The cocoons were at first neglected and finally carried by the workers to the refuse heap. On opening them I found in each a perfectly formed pseudogyne that must have died when very nearly ready to hatch. Some of these were as small as the smallest, but the majority were as large as the average *melanotica* workers. In two specimens, represented in Plate IV, Figs. 50–52, the thorax is seen to be more like that of the queen than in the pseudogynes of *F. incerta*.

3. *F. fusca* var. *neorufibarbis* Emery.

A single pseudogyne taken in Salt Lake County, Utah, by Mr. C. V. Chamberlin. In this specimen, which is smaller than the average worker, the dark thoracic blotches of the female are clearly indicated.

4. *F. sanguinea rubicunda* var. *subintegra* Emery.

(a) Two pseudogynes taken August 8, 1903, near Colorado Springs, Colorado, from a colony containing *F. fusca* var. *argentata* Wheeler as slaves.

(b) A single pseudogyne from a small colony taken August 13, 1903, in Cheyenne Cañon, Colorado. The slaves in this colony belonged to *F. argentata* and *F. subpolita* Mayr.

If we accept Wasmann's theory of the constant association of Lomechusini and pseudogynes, we must believe either that the single species, *X. cava*, breeds in the nests of several of our species of *Formica*, or that this name covers several closely allied species of *Xenodusa*, each with its normal host, but as yet undistinguished by coleopterists. Wasmann's description of different varieties of *X. cava*[1] may, perhaps, be regarded as supporting

[1] Revision der Lomechusa-Gruppe. Deutsch. ent. Zeitschr., 1896, pp. 244–256.

the latter alternative. But there is still another possibility which I cannot regard as altogether precluded in the present state of our knowledge, namely, that Wasmann's theory may be too concisely formulated, and that pseudogynes may occasionally be produced even in colonies that have never been infested with Lomechusini. This would, indeed, be very probable if, as I have supposed, the pseudogynes arise from female larvæ that have been merely neglected by their nurses at a particular stage of development.

Even more fragmentary than our knowledge of *X. cava* is our knowledge of the other species of the genus. Wasmann recognizes three additional species from North America: *montana* Casey[1] from California, *caseyi* Wasm. from Colorado,[2] and *sharpi* Wasm. of Mexico.[3] Many years ago Walker described from Vancouver an *Atemeles reflexus*[4] which is probably the same as *X. cava,* and Fall[5] has recently described from southern California a *Lomechusa angusta,* which is a *Xenodusa* and may prove to be a synonym of Wasmann's *X. caseyi,* the smallest of our species.

The ethological notes accompanying the descriptions of these various species are very brief. According to Schwarz,[6] *X. montana* has been taken in the nests of *Camponotus lævigatus* F. Smith, an ant which hardly descends below 6,000 feet in the Rocky Mountains and Sierras, and P. M. Wirtner, O. S. B., according to Wasmann,[7] has taken this same beetle in the nests of *Formica subpolita* in Colorado. *X. montana* seems, therefore, to be heterœcious like *X. cava.* Father Wirtner also took the type of *X. caseyi* in the nest of *F. subpolita. X. sharpi* was found in a nest of *Camponotus auricomus.* One of the type specimens of *X. angusta* was taken by Dr. A. Fenyes "with ants in a large oak gall." It is probable that these ants belonged to some form of *Camponotus marginatus* as this is, according to my observations, the commonest and most widely distributed ant nesting in oak galls in the southwestern States. If this is the case, and if, as I suspect, *X. angusta* is the same as *X. caseyi,* this species would seem to be heterœcious like *X. cava* and *montana.*

Whether there are any *Xenodusæ* that are regularly or even occasionally monœcious with species of *Camponotus* cannot be decided at the present time. Wasmann entertains this possibility because pseudogynes of this genus have been described, and their existence would *ex hypothesi* require the rearing of *Xenodusa* larvæ by *Camponotus.* Emery has described a

[1] Descriptions of North American Coleoptera, I. Bull. Calif. Acad. Sci., II, 1886–87. p. 202, 203.
[2] Eine neue Xenodusa aus Colorado mit einer Tabelle der Xenodusa-Arten. Deutsch. Ent. Zeitschr., 1897, II, p. 273, 274.
[3] Revision der Lomechusa-Gruppe, *l. c.*
[4] In Lord, The Naturalist in Vancouver Island and British Columbia, II, 1899, p. 317, 318.
[5] List of the Coleoptera of Southern California. Occas. Papers. Calif. Acad. Sci., VIII, 1901, pp. 219, 220.
[6] Myrmecophilous Coleoptera, etc., *loc. cit.*, p. 246.
[7] Zur Biologie der Lomechusa-Gruppe, *loc. cit.*, p. 275.

pseudogyne of a variety of *C. senex* Fabr. from Bolivia,[1] and Miss Holliday[2] has called attention to a couple of pseudogynes of *C. maculatus vicinus* Mayr. var. *nitidiventris* Emery collected by Professor Harold Heath at San Jose, California. Very recently Emery has discovered a pseudogyne of *C. igneus* (?) in the Baltic amber.[3] In another place[4] he has described what he regards as a pseudogyne of a Myrmicine ant, *Pheidologeton diversus,* of India. I figure some specimens of two different varieties of *Myrmica rubra* (*sulcinodoides* and *schencki*) which have a thoracic structure that may properly be called pseudogynic (Pl. IV, Figs. 45 and 46, 48 and 49) when compared with that of the normal worker (Fig. 47). The mesonotum is distinct and unusually convex, and there are clear traces of scutellar and metanotal sclerites. Some specimens (Fig. 45) bear vestiges of wings like those of the pterergates. As there is little probability that such forms are due to Lomechusini, it has been suggested that other parasites may be responsible for their production. I am inclined to believe that they arise occasionally even in uninfested colonies. If it be true that these anomalies as well as the above described pseudogynes of *Formica* arise from neglected immature female larvæ, it should be possible to produce them artificially by separating such larvæ from their nurses for several days. During the coming summer I hope to take up some experiments with this end in view.

4. The Commensalism of Metopina.

The parasitic insects considered in the preceding sections of this article are of more than usual interest because they produce certain effects noticeable both in the structure and behavior of their Formicid hosts. While all these effects are wrought through a withdrawal of nourishment from the developing larvæ, each natural group of parasites adopts a different method. Thus the ectoparasitic *Orasema* larva extracts important juices from the body of the *Pheidole* larva directly and with great rapidity, thereby reducing its host to a mere skin, which, though still able to pass on to the pupal stage, no longer possesses sufficient substance or vitality to reach the imaginal stage. The *Mermis* larva develops much more slowly within the alimentary tract of the ant larva and appropriates a portion of the food before it has been metabolized and converted into living compounds of high morphogenic potential. Finally, the presence of the Lomechusini within the *Formica*

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[1] Intorno al Torace delle Formiche. Boll. Soc. Ent. Ital., XXXII, 1900, p. 17 (of extract), fig. 14.
[2] Some Ergatogynic Ants, *loc. cit.*, pp. 313–315, fig. K.
[3] Deux Fourmis de l'Ambre de la Baltique. Bull. Soc. Ent. France, Année 1905, No. 13, p. 189, fig. 2.
[4] Zur Kenntniss des Polymorphismus, *loc. cit.*, p. 605–608, figs.

nest leads to a withholding of the necessary food from the larvæ, or, if Wasmann's view be adopted, at least to a withholding of the proper kind of food.

All of the above insects are ravenous parasites which ultimately destroy their hosts either individually or as communities. The insect to be described in the following paragraphs is much more benign, for if it surreptitiously appropriates some of the food that has been given to the larval ant, the amount it consumes seems to cause no serious inconvenience to its host. It is conceivable, however, that the presence of this commensal in great numbers might lead to very appreciable disturbances in the trophic status of a colony. The insect is a little Dipteron fly, whose larval and pupal stages I described in a paper published some years ago.[1] At that time I was unable to breed the imago and could only state that it was in all probability one of the Phoridæ. During the late autumn of 1901 Mr. C. T. Brues succeeded in rearing the adult insect from some larvæ which I gave him. He has since described it as *Metopina pachycondylæ*.[2] Much of my former account is here reproduced in a slightly altered form, together with an enlarged photograph (Pl. V, Fig. 69) of the larvæ and pupæ of both host and commensal.

On October 27, 1900, I made a short excursion to Mt. Barker, which is hardly more than an hour's walk from the university at Austin, Texas. The woods about the base and on the slopes of the elevation are favorite nesting grounds for the large black Ponerine ant, *Pachycondyla harpax* Fabr. In October this ant is rearing its second brood of larvæ and pupæ, having completed the education of its first brood during June and July.[3] Wishing to continue some observations on the babits of *Pachycondyla,* I dug up one of the largest colonies I could find and carried it home in a bag. On transferring it to a Lubbock nest I took the census of the colony and found it to comprise 25 worker ants, 13 cocoons, 8 mature larvæ, 7 immature larvæ, and a packet of eggs. While counting the larvæ, which are shaped like the well-known cucurbitaceous product known as the "crooked-necked squash," and covered with hairy tubercles, I noticed that six of the largest and one of the smallest presented an unusual appearance. Each of these seemed to wear about its neck a huge collar — a kind of Elizabethan ruff — consisting of a curled larva (Pl. V, Fig. 69 *x*). That this could not be another ant-larva was apparent from a moment's examination. In all cases it almost completely encircled the ant-larva in the region of the first abdominal, or in some cases the metathoracic, segment. The posterior end

[1] An Extraordinary Ant-guest. Am. Naturalist, XXXV, 1901, pp. 1007–1016, 2 figs.
[2] A Monograph of the North American Phoridæ. Trans. Am. Ent. Soc., XXIX, No. 4, 1903, p. 384.
[3] For an account of the habits of this ant, see my paper, A Study of Some Texan Ponerinæ. Biol. Bull., Vol. II, No. 1 (Oct. 1900), pp. 1–31, figs. 1–10.

was provided with a kind of disk, which adhered so tightly that both larvæ could be killed in alcohol without separating. The collar-like larva was broad behind the middle, but tapered anteriorly to a very slender thoracic region and head provided with small jaws (Fig. 69 *z*). These were supported by a chitinous frame-work of such characteristic structure as to show that the adult form must be a true Dipteron. The very smooth and tense integument, which was armed with some short, hooked bristles, was very transparent, so that the peristaltic movements of the viscera were clearly visible.

As soon as the ants had been transferred to the Lubbock nest they were given a number of young larvæ of *Camponotus maccooki* var. *sansabeanus* Buckley. These they soon proceeded to malaxate with their mandibles, twirling the morsels about in the meantime with their fore legs and lapping up the exuding juices with their tongues. Finally they deposited the crumpled and pulpy remains of the *Camponoti* on the trough-like ventral surfaces of their larvæ, which had been previously placed on their backs in a rough chamber dug in the earth of the nest. This chamber was immediately under the glass roof-pane, so that further developments could be closely observed with a pocket lens. Each ant-larva at once stretched forth its head eagerly and began to devour the viands with which it had just been provided. At the same moment the Dipteron larva, too, as if sniffing the odor of the fresh food, unwound its tapering neck from the ventral surface of its host, and without shifting the attachment of its posterior end, at once plunged its mandibles into the food. Under the lens both larvæ could be seen greedily dining side by side till the last particle of *Camponotus* larva had been consumed or prematurely removed by the worker ants.

When the ant-larvæ were huddled close together, a collar-like larva was sometimes observed to reach over and help itself from the food supply of a neighbor; but even when thus compelled to crane its neck to the utmost, it never shifted the attachment of its caudal end. Sometimes when there was no food within reach it would tweak with its sharp little jaws the sensitive hide of a neighboring ant-larva, till the latter squirmed with pain. It would sometimes even tweak its own host, as if to make it wriggle and perhaps thereby incite the worker ants to bring a fresh supply of provisions.

The following day two living myriopods (*Lithobius*) were placed in the nest. During the morning hours they were killed by the *Pachycondyla* workers, shorn of their many legs, cut up into pieces of convenient length, malaxated, and fed to the larvæ as on the preceding day. And again I was able to witness the strange banquet — the dwarf reaching down from the shoulders of the ogre and helping himself from the charger formed by the trough-like belly of his host. The same observation was repeated on sev-

eral consecutive days. Pieces of various ant-larvæ, beetle-larvæ, *Lithobius*, *Scutigera*, *Oniscus*,— all were served up to the ant-larvæ and partaken of with great relish by the Dipteron larvæ as well. There could be no doubt that the latter were true commensals,— perhaps the most perfect commensals, in the original meaning of the term, to be found in the whole animal kingdom!

As one of the smallest *Pachycondyla* larvæ, scarcely one-fourth grown, bore a very small Dipteron larva, it is, perhaps, safe to say that the ant-larva acquires its commensal at a very early age. The two then grow up together, so that there is always a certain relation between the two kinds of larvæ — large *Pachycondyla* larvæ bearing large commensals, and *vice versâ*. The worker ants lick and cleanse the commensals at the same time that they are caring for their own larvæ. This is usually done after meals. Since, during this operation of cleansing, the ants spend no more time over the commensals than they do on a similar area of the body surface of their own larvæ, it would seem that they are not even aware of the existence of the commensals. To these nearly blind ants, which must rely almost exclusively on their senses of smell and touch, the larvæ bearing commensals, if distinguished at all from individuals without these satellites, would probably be perceived merely as having unusually protruding necks. But there is nothing to indicate that these insects are really capable of perceiving such differences in their environment.

On the 5th of November I obtained satisfactory evidence that the *Metopina* larva is not obliged to remain always with the same *Pachycondyla* larva. During the night one of the large larvæ had moved and attached itself to the first abdominal segment of an ant larva which already bore a commensal around its metathoracic segment. The two larvæ were oriented in opposite directions, *i. e.*, with their heads reaching around opposite sides of their host. Subsequently one of these commensals moved to an unoccupied *Pachycondyla* larva. I was not present when the change occurred, nor was I able to determine whether it was the originally stationary or the adventitious larva that moved. Although this observation makes it certain that the *Metopina* larvæ can shift their position from one host to another, I am convinced, nevertheless, that they must do this with great reluctance and only under urgent circumstances, such as extreme hunger, the death of the larva to which they are attached, or, perhaps, when fully mature and about to pupate.

As the days passed, the mature ant-larvæ spun their brown cocoons (Pl. V, Fig. 69 *u*) one by one, and one by one the mature commensals disappeared. Did they also pupate and for this purpose conceal themselves in the soil of the nest? Or had the ants at last detected the villains and

converted them into food for the larvæ which had not yet pupated? Or did they stick to their hosts and pupate within the cocoons? In order to ascertain, if possible, the true state of affairs, I transferred the whole colony to a fresh nest and examined the soil of the old nest with great care. There were no traces of the missing commensals. The only remaining resource was to open the cocoons. Several of the cocoons which had been taken with the nest October 27 had hatched, but by November 10 there were still thirteen cocoons in the nests, as several of the larvæ had pupated in the meantime. Five of these were opened, and in two, which contained semi-pupæ of *Pachycondyla* and were, therefore, of recent formation, commensals were found! Having shared the table of their host, they had come to share its bed as well. The *Metopina*, too, had pupated after the manner of its kind — forming a puparium; *i. e.*, instead of spinning a cocoon like the ant larva, the dead larval skin, somewhat shriveled and contracted, was used as an envelope, and within this the pupa proper was formed.

This puparium, represented in Plate V, Fig. 69 *v*, is from 2.25 to 2.5 mm. long and clearly of the cyclorhaph type. It is elliptical, much flattened dorso-ventrally, especially along the edges, which are thin and hyaline and almost alate. The brownish dorsal surface is thrown into delicate and irregular transverse wrinkles. Anteriorly, in the thoracic region, there is a pair of short black respiratory tubes. The ventral surface is very glabrous and distinctly paler than the dorsal surface.

Subsequently, several other cocoons were opened and two more were found to contain the puparia of commensals. In all four cases the puparium was invariably located in the caudal pole of the cocoon, just to one side of the black blotch of ejecta deposited by the ant-larva before becoming a semipupa. At this point the puparium was immovably stuck to the wall of the cocoon by means of its smooth ventral surface. Its anterior end was directed towards the cephalic pole. As there is always considerable space, especially at the posterior pole, between the walls of the cocoon and the enclosed ant-pupa, the much flattened fly puparium did not in the least crowd its host.

It would be interesting to know what the commensal larva is doing while the ant-larva is weaving its cocoon. Does it move about to avoid the swaying jaws of the spinning larva? Or does it take up its position from the first at the posterior end of the larval ant and there remain motionless while the posterior pole of the cocoon is being completed? It is very difficult to answer these questions. The fact that the posterior poles of all the cocoons containing puparia were somewhat distorted, being broader, more obtuse, and more irregular than the normal cocoons, would seem to indicate that the ant-larva may modify this end of its cocoon for the better accom-

modation of the commensal. I am inclined to believe, however, that the distortion may be produced by the *Metopina* larva while attaching itself just before pupating to the newly woven and still plastic cocoon.

Reflection shows that the position of the puparium in the posterior pole of the cocoon, though the reverse of the position of the larval commensal with respect to its larval host, is the only one which can be maintained by the commensal with perfect safety. Like other ants, the *Pachycondyla* leaves its cocoon through a rent in the anterior pole. This rent is certainly made by the mandibles of the hatching ant, and it is possible that the callow insect may succeed in making its way out of the cocoon without any assistance from the workers. I have hitherto failed, however, to surprise one of these ants in the act of hatching. But even if the obstetrical aid of the workers is necessary, as it is in the more highly specialized Camponotinæ, any position for the commensal puparium, except at the posterior pole of the cocoon, might be fatal, for the struggling jaws and legs of the emerging ant and the jaws of the assisting ants would certainly be very liable to cut into so delicate an object attached to the anterior or median walls of the cocoon.

At this point my first set of observations on the *Metopina* ended. The Phorid puparia were kept for several weeks in what I supposed to be the proper conditions of warmth and moisture, but to my intense disappointment they failed to hatch. During the autumn and winter frequent and diligent search was made for more of the commensals in all the *Pachycondyla* nests I could find, but in vain. Finally, during the latter part of May of the following year, I discovered in a very different locality two *Pachycondyla* nests which contained a few *Metopina* larvæ. This discovery proved that the Phorid is double-brooded like its host. But the larvæ were very small and attached to such very young ant-larvæ that I despaired of being able to raise them in my artificial nests as far as the imaginal stage. The search for *Pachycondyla* nests containing *Metopinæ* was again renewed in the fall. Two colonies were found, and from one of these Mr. Brues succeeded in rearing several of the imaginal flies. These measure 2 mm. in length, are black with yellowish brown legs and antennæ and clear, hyaline wings. As yet *M. pachycondylæ* is the only known North American species of the genus.

It is not difficult to imagine the circumstances under which the *Metopina* hatches and manages to lay its eggs in the same or other *Pachycondyla* nests. Undoubtedly the ant is the first to hatch and to leave the cocoon. Now very soon after this occurs, the useless cocoon is always carried by a worker and placed on the refuse heap, which in the natural nest is often almost entirely made up of the empty cocoons of from one to several broods of ants, and lies in a rather dry and well-ventilated spot immediately beneath the

stone covering the nest. Along with the cocoon is carried the *Metopina* puparium still adhering to the wall at its unopened posterior end. Thus after a privileged existence as free pensioner and bedfellow to a generous host, it is unwittingly carried away in the worn-out bedclothes and consigned to the family rag pile. Here the small and very active Dipteron hatches, leaves by the wide-open front door of the cocoon, and, after mating, either returns to lay a few eggs in the galleries of its former host, or flies away to oviposit in some other *Pachycondyla* nest. Thus the simple fact that the *Metopina* hatches later than the ant renders it unnecessary for the fly to possess some peculiar means of perforating the tough wall of the cocoon, and also accounts for the position of the puparium in the posterior pole, where it would be completely concealed from the workers even after the escape of the callow ant.

In conclusion attention may be directed to certain particulars of special interest in connection with the life history of the *Pachycondyla* commensal: First, the peculiar habits of the Phorid show clearly that the Ponerine method of feeding the larvæ with comminuted insects is not only the typical but the only method employed by these ants, for such a commensal would certainly starve if the *Pachycondyla* larvæ were carefully fed like the larvæ of *Camponotus* and *Formica*, by regurgitation of liquid from the mouths of the workers. The Phorid profits by a peculiarity in the behavior of its host, and thereby demonstrates — by one of Nature's experiments — that *Pachycondyla harpax* does not feed its young by regurgitation. Second, in the peculiar symbiotic relationship existing between the Phorid and the ants, the adaptations are all on the side of the former, whereas the latter pursues its ancient and well-established mode of life uninfluenced by and apparently in complete ignorance of the very existence of its little guests. Even the distortion of the cocoon may be entirely due, as I have suggested, to the activity of the *Metopina*. These strikingly unilateral adaptations are probably to be explained on the ground that the Phorid is so careful and conservative of the life and welfare of its host. The small amount of food consumed by the little commensals can hardly be a serious drain on the provisioning instincts of the Ponerinæ, at least under ordinary conditions. The larvæ bearing the commensals were certainly as large and healthy as any others in the nest, and produced perfectly normal pupæ, which in the cases observed all lacked the imaginal disks for the wings and were therefore of the worker type.

PART II. CONCERNING THE POLYMORPHISM OF ANTS.

There is a sense in which the term polymorphism is applicable to all living organisms, since no two of these are ever exactly alike.[1] But when employed in this sense, the term is merely a synonym of 'variation', which is the more apt, since polymorphism has an essentially morphological tinge, whereas variation embraces also the psychological, physiological, and ethological differences between organisms. In zoölogy the term polymorphism is progressively restricted, first, to cases in which individuals of the same species may be recognized as constituting two or more groups, or castes, each of which has its own definite characters or complexion. Second, the term is applied only to animals in which these intraspecific groups coëxist in space and do not arise through metamorphosis or constitute successive generations. Cases of the latter description are referred to 'alternation of generations' and 'seasonal polymorphism.' And third, the intraspecific groups which coincide with the two groups of reproductive individuals existing in all gonochoristic, or separate-sexed Metazoa are placed in the category of 'sex' or 'sexual dimorphism.' There remain therefore as properly representing the phenomena of polymorphism only those animals in which characteristic intraspecific and intrasexual groups of individuals may be recognized, or, in simpler language, those species in which one or both of the sexes appear under two or more distinct forms.

As thus restricted polymorphism is of rare occurrence in the animal kingdom and may be said to occur only in colonial or social species, where its existence is commonly attributed to a physiological division of labor. It attains to its clearest expression in the social insects, in some of which, like the termites, we find both sexes equally polymorphic, while in the others like the ants, social bees, and wasps, the female alone, with rare exceptions, is differentiated into distinct castes. This restriction of polymorphism to the female in the social Hymenoptera, with which we are here especially concerned, is easily intelligible if it be traceable, as is usually supposed, to a physiological division of labor, for the colonies of ants, bees, and wasps are essentially more or less permanent families of females, the male representing merely a fertilizing agency temporarily intruding itself on the activities of the community at the moment it becomes necessary to start other colonies. We may say, therefore, that polymorphism among social Hymenoptera is a physical expression of the high degree of social plasticity and efficiency of the female sex among these insects. This is shown more specifically in two

[1] The term is used in this sense by Waxweiler, for example, in his admirable 'Esquisse d'une Sociologie,' Brussels, 1906, pp. 141–143.

characteristics of the female, namely the extraordinary intricacy and amplitude of her instincts which are thoroughly representative of the species, and her ability to reproduce parthenogenetically. This, of course, means a considerable degree of autonomy even in the reproductive sphere. But parthenogenesis, while undoubtedly contributing to the social efficiency of the female, must be regarded and treated as an independent phenomenon, without closer connection with polymorphism, for the ability to develop from unfertilized eggs is an ancient characteristic of the Hymenoptera and many other insects, which made its appearance among the solitary species, like the Tenthredinidæ and Cynipidæ, long before the development of social life. Moreover, polymorphism may occur in male insects which, of course, are not parthenogenetic. That parthenogenesis is intimately connected with sexual dimorphism, at least among the social Hymenoptera, seems to be evident from the fact that the males usually if not always develop from unfertilized, the females from fertilized eggs.

While the bumble-bees and the wasps show us the incipient stages in the development of polymorphism, the ants as a group, with the exception of a few parasitic genera that have secondarily lost this character, are all completely polymorphic. It is conceivable that the development of different castes in the female may have arisen independently in each of the three groups of social Hymenoptera, although it is equally probable that they may have inherited a polymorphic tendency from a common extinct ancestry. On either hypothesis, however, we must admit that the ants have carried the development of female castes much further then the social bees and wasps, since they have not only produced a wingless form of the worker, in addition to the winged female, or queen, but in many cases also two distinct castes of workers known as the worker proper and the soldier. Some systematists have, therefore, appropriately separated them from all other Hymenoptera as 'Heterogyna.'

Different authors have framed very different conceptions of the phylogenetic beginnings of social life among the Hymenoptera and consequently also of the phylogenetic origin and development of polymorphism. Thus Herbert Spencer evidently conceived the colony as having arisen from a consociation of adult individuals. I infer this from his remarks on the origin of the amazon colony in his well-known reply to Weismann:[1] "Some variety of them [the amazon ants] led to swarm — probably at the sexual season — did not disperse again as soon as other varieties. Those which thus kept together derived advantages from making simultaneous attacks on prey and prospered accordingly. Of descendants the varieties which carried

[1] A Rejoinder to Professor Weismann. Contemp. Review, Sept. 1893, p. 14.

on longest the associated state prospered the most; until, at length, the associated state became permanent. All of which social progress took place while there existed only perfect males and females." Although Spencer is particularly unfortunate in selecting a parasitic ant like the amazon (*Polyergus rufescens*) on which to hang his hypothesis, there are a few facts which would seem to make his view applicable to other social Hymenoptera. Fabre [1] once found some hundreds of a species of solitary wasp (*Ammophila hirsuta*) huddled together under a stone on the summit of Mt. Ventoux in the Provence at an altitude of about 5,500 feet, and Forel [2] found more than fifty deälated females of *Formica rufa* under similar conditions on the Simplon. I have myself seen collections of a large red and yellow *Ichneumon* under stones on Pike's Peak at an altitude of more than 13,000 feet, and a mass of about seventy deälated females of *Formica fusca* var. *gnava* Buckley apparently hibernating after the nuptial flight under a stone near Austin, Texas. I am convinced, however, that such congregations are either entirely fortuitous, especially where the insects of one species are very abundant and there are few available stones, or, that they are, as in the case of *F. rufa* and *gnava*, merely the result of highly developed social proclivities and not a manifestation of such proclivities in process of development.

A very different view from that of Spencer is adopted by most authors. They regard the insect society as having arisen, not from a chance concourse of adult individuals but from a natural affiliation of mother and offspring. This view which has been elaborated by Marshall [3] among others, presents many advantages over that of Spencer, not the least of which is its agreement with what actually occurs in the founding of the existing colonies of wasps, bumble-bees and ants. These colonies pass through an ontogenetic stage which has all the appearance of repeating the conditions under which colonial life first made its appearance in the phylogenetic history of the species — the solitary mother insect rearing and affiliating her offspring under conditions which would seem to arise naturally from the breeding habits of the nonsocial Hymenoptera. The exceptional methods of colony formation seen in the swarming of the honey bee and in the temporary and permanent parasitism of certain ants, are too obviously secondary and comparatively recent developments to require extensive comment. The bond which held mother and daughters together as a community was from the first no other than that which binds human societies together — the bond

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[1] Souvenirs Entomologiques. I, 3 ed., 1894, pp. 187, 188, 196 *et seq.*
[2] Fourmis de la Suisse, p. 257.
[3] Leben and Trieben der Ameisen. Leipzig, 1889, pp. 3–6.

of hunger and affection so beautifully described in the famous lines from Schiller's "Die Weltweisen":

> Einstweilen, bis den Bau der Welt
> Philosophie zusammenhält,
> Erhält sie [Natur] das Getriebe,
> Durch Hunger und durch Liebe.

The daughter insects in the primitive colony became dependent organisms as a result of two factors: inadequate nourishment and the ability to pupate very prematurely. But this very ability seems to have entailed an incompleteness of imaginal structure and instincts which in turn must have confirmed the division of labor and thus tended to perfect the social organization.

Before further discussing the problems suggested by this view of the origin of the colony and the general subject of polymorphism, it will be advisable to pass in review the series of different phases known to occur among ants. This review will be facilitated by consulting the diagram on Plate VI, in which I have endeavored to arrange the various phases so as to bring out their morphological relations to one another. The phases may be divided into two main groups, the normal and the pathological. In the diagram the names of the latter are printed in italics. The normal phases may again be divided into primary or typical, and secondary or atypical, the former comprising only the three original phases, male, female, and worker, the latter the remaining phases, which, however, are far from all having the same status or frequency. The three typical phases are placed at the angles of an isosceles triangle, the excess developments being placed to the right, the defect developments to the left, of a vertical line passing through the middle of the diagram. The arrows indicate the directions of the affinities of the secondary phases and suggest that those on the sides of the triangle are annectant, whereas those which radiate outward from its angles represent the new departures with excess and defect characters.

1. The Typical, Atypical and Pathological Phases of Ants.

(1) The *male* (anēr) is far and away the most stable of the three typical phases which are found in all but a few monotypic and parasitic genera of ants. This is best shown in the general uniformity of structure and coloration which characterize this sex in genera whose female forms (workers and queens) are widely different; *e. g.*, in such a series of cases as *Myrmecia, Odontomachus, Cryptocerus, Formica, Pheidole*, etc. In all of these genera the males are very similar, at least superficially, whereas the workers and females are very diverse. The body of the male ant is graceful in form, one might almost say emaciated. Its sense-organs (especially the eyes and antennæ), wings and genitalia are highly developed; its mandibles are

more or less undeveloped and in correlation with them the head is portionally shorter, smaller and rounder than in the females and workers of the same species. Even when the latter phases have brilliant or metallic colors, as in certain species of *Macromischa* and *Ectatomma*, the males are uniformly red, yellow, brown or black. Yet notwithstanding this monotony of structure and coloration, the male type may present the following interesting modifications.

(2) The *macranēr* is an unusually large form of male which occasionally occurs in populous colonies.

(3) The *micranēr*, or dwarf male, differs from the typical form merely in its smaller stature. Such forms often arise in artificial nests.

(4) The *dorylanēr* is an unusually large male form peculiar to the driver and legionary ants of the subfamily Dorylinæ (*Dorylus* and *Eciton*). It is characterized by its large and peculiarly modified mandibles, long cylindrical gaster and singular genitalia. It may be regarded as an aberrant macranēr that has come to be the typical male of the Dorylinæ.

(5) The *ergatanēr*, ergatomorphic, or ergatoid male resembles the worker in having no wings and in the structure of the antennæ. It occurs in the genera *Ponera*, *Formicoxenus*, *Symmyrmica*, and *Cardiocondyla*. In certain species of *Ponera* (*P. punctatissima* and *ergatandria*) and in *Formicoxenus nitidulus* the head and thorax are surprisingly worker-like, in other forms like *Symmyrmica chamberlini* these parts are more like those of the ordinary male ant, while *P. eduardi* shows a more intermediate development of the head with a worker-like thorax. Forel,[1] has recently shown that the ergatanēr may coëxist with the anēr, at least in one species of *Ponera* (*P. eduardi* Forel). In other words, this ant has dimorphic males.

(6) The *gynæcanēr*, or gynæcomorphic male occurs in certain parasitic and workerless genera (*Anergates* and *Epœcus*) and resembles a female rather than a worker form. The male of *Anergates* is wingless, but has the same number of antennal joints as the female. In *Epœcus* both sexes are very much alike and both have 11–12-jointed antennæ.[2]

(7) The *phthisanēr* is a pupal male which in its late larval or semipupal state has its juices partially exhausted by an *Orasema* larva. This male is too much depleted to pass on to the imaginal stage. The wings are suppressed and the legs, head, thorax, and antennæ remain abortive.

(8) The *female* (gynē), or queen, is the more highly specialized sex among ants and is characterized, as a rule, by her large stature and the more uniform development of her organs. The head is well developed and

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[1] Dimorphisme du Mâle chez les Fourmis. Ann. Soc. Ent. Belg., XLVIII, 1904.

[2] For an account of the ergatandric and gynæcandric forms see Emery, 'Zur Kenntniss des Polymorphismus der Ameisen,' Biol. Centralbl., XXVI, 1906, pp. 624–630, 4 figs.

provided with moderately large eyes, ocelli, and mandibles; the thorax is large (macronotal) and presents all the sclerites of the typical female Hymenopteron; the gaster is voluminous and provided with well developed reproductive organs. The wings and legs are often relatively smaller than in the male.

(9) The *macrogyne* is a female of unusually large stature.

(10) The *microgyne*, or dwarf female, is an unusually small female which in certain ants, like *Formica microgyna* and its allies, is the only female of the species and may be actually smaller than the largest workers. In other ants, like certain species of *Leptothorax* and *Myrmica* microgynes may sometimes coëxist in the same nests with the typical females.

(11) The *β–female* is an aberrant form of female such as occurs in *Lasius latipes*, either as the only form or coëxisting with the normal female which is then called the α-female. In this case, therefore, the female is dimorphic. The β-female is characterized by excess developments in the legs and antennæ and in the pilosity of the body.

(12) The *ergatogyne*, ergatomorphic, or ergatoid female, is a worker-like form but with large eyes, ocelli, and a thorax more or less like that of the female, but without wings. Such females occur in a number of species of ants. They have been seen in *Myrmecia, Odontomachus, Anochetus, Ponera, Polyergus, Leptothorax, Monomorium*, and *Cremastogaster*. There is nothing to prove that they are pathological in origin. In fact, in *Monomorium floricola* and certain species of *Anochetus* they seem to be the only existing females. In other cases, like *Ponera eduardi*, as Forel has shown, they occur with more or less regularity in nests with normal workers. They occur also under similar conditions in colonies of the circumpolar *P. coarctata*, and probably also among other species of the genus.

(13) The *dichthadiigyne*, or dichthadiiform female is peculiar to the ants of the subfamily Dorylinæ. It is wingless and stenonotal, destitute of eyes and ocelli, or with these organs very feebly developed, and with a huge elongated gaster and extraordinary, voluminous ovaries.

(14) The *pseudogyne* has been sufficiently characterized in the preceding pages as a worker-like form with enlarged mesonotum and sometimes with traces of other thoracic sclerites of the female, but without wings or very rarely with wing vestiges.

(15) The *phthisogyne* arises from a female larva under the same conditions as the phthisanēr, and differs from the typical female in the same characters, namely absence of wings, stenonoty, microcephaly and microphthalmy. It is unable to attain to the imaginal instar.

(16) The *worker* (ergates) is characterized by the complete absence of wings and a very small (stenonotal) thorax, much simplified in the structure of its sclerites. The eyes are small and the ocelli are usually absent or,

when present, extremely small. The gaster is small, owing to the undeveloped condition of the ovaries. A receptaculum seminis is usually lacking, and the number of the ovarian tubules is greatly diminished.[1] The antennæ, legs and mandibles are well developed.

(17) The *gynæcoid* is an egg-laying worker. It is a physiological rather than a morphological phase, since it is probable that all worker ants when abundantly fed become able to lay eggs. Wasmann[2] observed in colonies of *Formica rufibarbis* that a few of the workers became gynæcoid and functioned as substitution queens. In colonies of the Ponerine genus *Leptogenys* (including the subgenus *Lobopelta*), and probably also in *Diacamma* and *Champsomyrmex*, the queen phase has disappeared and has been replaced by the gynæcoid worker.

(18) The *macrergate* is an unusally large worker form which in some species is produced only in populous or affluent colonies (*Formica, Lasius*).

(19) The *micrergate,* or dwarf worker, is a worker of unusually small stature. It appears as a normal or constant form in the first brood of all colonies that are founded by isolated females.

(20) The *dinergate,* or soldier is characterized by a huge head and mandibles, often adapted to particular functions (fighting and guarding the nest, crushing seeds or the hard parts of insects), and a thoracic structure sometimes approaching that of the female in size or in the development of its sclerites (*Pheidole*).

(21) The *desmergate* is a form intermediate between the typical worker and dinergate, such as we find in more or less isolated genera of all the subfamilies except the Ponerinæ, *e. g.*, in *Camponotus,* some species of *Pheidole, Solenopsis,* and *Pogonomyrmex, Azteca, Dorylus, Eciton,* etc. The term might also be employed to designate the intermediate forms between the small and large workers in such genera as *Monomorium, Formica,* etc.

(22) The *plerergate,* 'replete,' or 'rotund,' is a worker which in its callow stage has acquired the peculiar habit of distending its gaster with stored liquid food ('honey') till this portion of the body is a large spherical sac and locomotion becomes difficult or even impossible. This occurs in the honey ants (some North American species of *Myrmecocystus,* some Australian *Melophorus* and *Camponotus,* and to a less striking extent in certain species of *Prenolepis* and *Plagiolepis*).

(23) The *pterergate* is a worker or soldier with vestiges of wings on a thorax of the typical ergate or dinergate form, such as I have described in certain species of *Myrmica* and *Cryptocerus.*[3]

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[1] Adlerz's often-cited statement that the ovarian tubules are completely lacking in the workers of *Tetramorium cæspitum* seems to me to require confirmation. These organs may be easily overlooked in dissecting such small ants. The study of stained sections of adult pupal workers would probably yield more satisfactory results.

[2] Ameisenarbeiterinnen als Ersatzköniginnen, *loc. cit.*

[3] Worker Ants with Vestiges of Wings. Bull. Am. Mus. Nat. Hist., XXI, 1905, pp. 405–408, pl. xiv.

(24) The *mermithergate,* which has been described in detail in the preceding pages, is an enlarged worker, produced by *Mermis* parasitism and often presenting dinergate characters in the thorax and minute ocelli in the head.

(25) The *phthisergate,* which corresponds to the phthisogyne and phthisanēr, is a pupal worker which in its late larval or semipupal stage has been attacked and partially exhausted of its juices by an *Orasema* larva. It is characterized by extreme stenonoty, microcephaly and microphthalmy, and is unable to pass on to the imaginal stage. It is in reality an infra-ergatoid form.

(26) The *gynandromorph* is an anomalous form in which male and female characters are combined in a blended or more often in a mosaic manner.

(27) The *ergatandromorph* is an anomaly similar to the last but having worker instead of female characters combined with those of the male.[1]

2. The Views of Some Previous Authors on Polymorphism.

In their attempts to explain polymorphism authors have not, of course, taken all of the above enumerated phases into consideration, but have been content to include only the typical and perhaps a few of the atypical and pathological phases. And it is clear that if the main phases could be accounted for, the rarer and less important deviations would present few difficulties. I shall endeavor to show, however, that some of these singular forms may shed at least a few rays of light on the problem of polymorphism.

The social insects have held an important place in discussions of evolution and heredity ever since Darwin called particular attention to these animals in the eighth chapter of the 'Origin.' In later years they assumed even greater prominence in the controversies between the Neolamarckians and Neodarwinians concerning the efficacy of natural selection. This was unavoidable, for polymorphism would seem to be of such a nature as to afford a test of the validity of any hypothesis bearing on the inheritance or noninheritance of acquired characters as well as of any hypothesis concerning the rôle of preformation, or epigenesis, in the development of organisms. As it will be impossible in this place to present a detailed history of the subject or to dwell on all its wider implications, I shall confine myself mainly to the views which were championed by Weismann and Herbert Spencer respectively in their well-known controversy in the 'Contemporary Review',

[1] For an account of the known cases of this and the preceding anomaly among ants see my paper: 'Some New Gynandomorphous Ants, with a Review of the Previously Described Cases.' Bull. Am. Mus. Nat. Hist., XIX, 1903, pp. 653–683, 11 figs.

and have been maintained with more or less modification by zoölogists down to the present time.[1]

In order to make his explanation of polymorphism conform with the remainder of his hypothesis of heredity, Weismann is compelled to assume, not only a set of germ-plasmic determinants for each of the sexes in ordinary sexual dimorphism, but a double set for the female in the social Hymenoptera and a double set for each sex in the termites. At least four sets must also be postulated for ants with differentiated worker and soldier castes. This is evident from the following quotation:[2]

"So when instead of dimorphism, there is polymorphism, when, for instance, the females of a species are similarly distinguished among themselves, and occur in two forms, this results, according to my idea, from the double determinants becoming triple determinants. If there were workers among the butterflies, and if these showed red color on the part of the wing that is blue in the male and brown in the female, there would always be three representative determinants present at a definite part of the extremely elaborate and highly complicated germ-plasm; but only one of these would become active during the development of the egg and sperm-cell concerned, and would produce the patch of brown or blue or red scales in the wing.

"According to this theoretical representation, every part of the body that is differently formed in the males, females and workers is represented in the germ-plasm by three corresponding determinants but in the development of the eggs, never more than one of these attains to value — *i. e.*, gives rise to the part of the body that is represented — and the others remain inactive.

"Thus, then, the metamorphosis of the body parts of the workers of ants and bees will have to be considered in connection with the fact that the males and females whose germ-plasm contains favorable variations of the determinants of the workers have a better prospect for the maintenance of their successors than others which showed less favorable variations of such determinants. The process of selection is the same as if the matter at issue were the attainment of favorable adaptations in the body of the sexual forms; for in both cases it is, as I have once before said, not really the body that is

[1] The papers called forth by this controversy are here cited in the order of their publication: Spencer: 'The Inadequacy of "Natural Selection",' Contemp. Rev., Feb. and March, 1893, pp. 153–166, 439–456; 'Professor Weismann's Theories,' *ibid.*, May, 1893, pp. 743–760; Weismann: 'The All Sufficiency of Natural Selection,' *ibid.*, Sept., 1893, pp 309–338; Spencer: 'A Rejoinder to Professor Weismann,' *ibid.*, Dec. 1893, pp. 893–912; 'Weismannism Once More,' *ibid.*, Oct. 1894, pp. 592–608. Weismann has also repeated or elaborated his views on the polymorphism of the social insects in the following works: 'Das Keimplasma. Eine Theorie der Vererbung.' Jena, Gustav Fischer, 1892, pp. 494–498; 'The Effect of External Influences upon Development,' Romanes Lecture, London, Henry Frowde, 1894, pp. 29–48; and 'Vorträge über Descendenz-theorie,' Jena, Gustav Fischer. 2 Bd. pp. 101–118. For an aftermath of the Spencer-Weismann controversy see also the discussion of the subject in 'Natural Science,' IV, 1894, by Ball (Neuter Insects and Lamarckism, pp. 91–97), and Cunningham (Neuter Insects and Darwinism, pp. 281–289).

[2] The All-Sufficiency, etc., *loc. cit.*, pp. 326, 327.

selected, but the germ-plasm from which the body develops. The difference is this: in the one case the survival in the struggle for existence depends on characters and variations of the body of the individual; in the other, only on the character of a certain kind of descendant — the worker. If the ant state were composed of individuals connected together like a colony of polypes or *Siphonophoræ,* a process of selection by which only the workers were changed would be within easier reach of our imagination, as these would then, in a manner, be only *organs,* just like the snaring-threads, the swimming bells, and the gastric tubes of the *Siphonophoræ.* As these do not reproduce, and accordingly can only vary by selection of the egg or germplasm from which the whole colony is formed, so in the case of the ant-colony, or rather state, the barren individuals or organs are metamorphosed only by selection of the germ-plasm from which the whole state proceeds. In respect of selection the whole state behaves as a single animal; the state is selected, not the single individuals; and the various forms behave like the parts of one individual in the course of ordinary selection."

It must be admitted that this hypothesis is boldly and clearly conceived and its author's knowledge of myrmecology and melittology is only surpassed by the adroitness with which he compells the facts to tally with his assumptions. Nowhere in Weismann's work are both the strength and the weakness of his elaborate architectonics of the germ-plasm more apparent than in this attempt to explain the complicated and adaptively correlated organization of the sterile worker as the result of a single mechanical factor, natural selection, acting on constellations of fortuitous determinants in the germplasm of the fertile female.

Spencer, too, seeks a mechanical explanation of the purposeful adaptations of the worker, though this is utterly at variance with the fundamental teleological spirit of the Lamarckian view which he elsewhere advocates. He starts out with the social wasps (*Vespa*), some species of which present an uninterrupted series of transitional forms between the small sterile worker and the large fertile female, or queen. He calls attention to the abundant evidence to show that these arise progressively and in close dependence on the food supply of the colony, so that the sterility and dwarfing of the workers are manifestly caused by insufficiency of food during their larval stages. He then proceeds to extend this same explanation to the ants, although these insects differ from the wasps in presenting great morphological differences between the workers and females. After considering the African driver ants which have highly polymorphic workers, he goes on to say: "In contrast with this interpretation, consider now that of Professor Weismann. From whichever of the two possible suppositions he sets out, the result is equally fatal. If he is consistent, he must say that each of these

intermediate forms of workers must have its special set of 'determinants,' causing its special set of modifications of organs; for he cannot assume that while perfect females and the extreme types of workers have their different sets of determinants, the intermediate types of workers have not. Hence, we are introduced to the strange conclusion that besides the markedly distinguished sets of determinants there must be to produce these intermediate forms, many other sets slightly distinguished from one another — a score or more kinds of germ-plasm in addition to the four chief kinds [namely for the male, female, soldier, and worker]. Next comes an introduction to the still stranger conclusion, that these numerous kinds of germ-plasm, producing these numerous intermediate forms, are not simply needless but injurious — produce forms not well fitted for either of the functions discharged by the extreme forms: the implication being that natural selection has originated these disadvantageous forms! If to escape from this necessity for suicide Professor Weismann accepts the inference that the differences among these numerous intermediate forms are caused by arrested feeding of the larvæ at different stages, then he is bound to admit that the differences between the extreme forms, and between these and perfect females, are similarly caused. But if he does this, what becomes of his hypothesis that the several castes are constitutionally distinct, and result from the operation of natural selection? Observe too that his theory does not even allow him to make this choice; for we have clear proof that unlikenesses among the forms of the same species cannot be determined this way or that way by differences of nutrition. English greyhounds and Scotch greyhounds do not differ from one another so much as do the Amazon-workers [soldiers] from the inferior workers, or the workers from the queens. But no matter how a pregnant Scotch greyhound is fed, or her pups after they are born, they cannot be changed into English greyhounds: the different germ-plasms assert themselves spite of all treatment. But in these social insects the different structures of queens and workers are determinable by differences of feeding. Therefore the production of their various castes does not result from the natural selection of varying germ-plasm."

If we omit the portion of Spencer's argument in which he postulates the dysteleological character of the intermediates, or desmergates, as I have called them — a probably erroneous assumption, since there is every reason to believe that individuals embodying varying combinations of the worker and soldier traits may be just as useful to the colony as the soldiers and workers themselves — the position taken in the above quotation seems to be unassailable. But when Spencer comes to deal with the crucial problem, namely the marvelous, purposeful coadaptation of organs in the sterile workers, he fails as signally as Weismann, for no one familiar with the habits

and taxonomy of ants can regard his attempts to trace such specialized structures and instincts as those of the amazon slave-makers (*Polyergus*) to inherited presocial acquirements as seriously invalidating Weismann's argument. As I shall show in the sequel, however, Spencer presents a vague adumbration of facts which have since come to light and easily dispose of the portion of Weismann's argument relating to the amazons.

Weismann returns to the charge in his Romanes lecture and asserts that he cannot look upon Spencer's view "as a correct one in the sense implied. It is certainly true that bees have it in their power to cause a larva to become a queen or a worker according to the manner in which they feed it: it is equally true of all animals that they reproduce only feebly or not at all when badly and insufficiently nourished: and yet the poor feeding is not the *causa efficiens* of sterility among bees but is merely the stimulus which *not only results in the formation of rudimentary ovaries, but at the same time calls forth all the other distinctive characters of the workers.* It appears to me to be doubly incorrect to look upon the poor nourishment as the actual cause; for such a view not only confuses the stimulus with the real cause, but also fails to distinguish between an organ that becomes rudimentary and one that is imperfectly developed. Moreover the fact is overlooked that the ovaries of the workers are actually rudimentary organs: a great proportion of their really essential parts have disappeared, while only a small remnant is retained."

Weismann goes farther and maintains that he has disproved Spencer's view experimentally. He reared two lots of blow-fly larvæ (*Musca vomitoria*), one on poor the other on abundant food, and obtained imaginal flies differing greatly in size but with the reproductive as well as the other organs normally developed even in the smallest individuals. The latter on being well fed, mated and produced normal young. He concludes as follows from this experiment: "By comparing the result of this experiment with the known facts as to bees, the difference in the behavior of the two organisms is made clear. In the case of bees a distinct degeneration of the ovaries and various accessory organs of reproduction takes place in consequence of poor nourishment; while in flies the whole reproductive apparatus is formed quite as perfectly when the nourishment of the larva is deficient as when it is ample. There is even no delay in the maturing of the eggs, as shown by the fact that the first batch was laid at exactly the same time as in the case of the flies arising from normally fed larvæ.

"It might, however, be said that flies and bees are very different organisms, and therefore react differently to external influences. This is quite true, and is exactly what I wish to be acknowledged. My experiments with the flies were merely meant to show that all insects, even though they

may resemble bees in some respects, do not react in a similar way to the bee to meagreness of nutrition, and that accordingly *this mode of reaction is a characteristic of bees*: — it is a new acquisition, and was not possessed by the ancestors of these insects."

The views of the more active European myrmecologists, Emery, Escherich, Forel and Wasmann, are in close accord with those of Weismann, but there are some significant departures, especially in Emery's view, which approaches that of Spencer. Emery gives this summary of his position in a paper on the origin and development of the worker among ants:[1] "The theory which I have attempted to carry out in hypothetical form, is based on the assumption, that the production of the worker depends on the instinctive art of breeding workers, and that the origin of the worker caste is to be attributed more to a difference in the quality, the differentiation of several kinds of workers more to the quantity of the food. From the latter process I would not, of course, exclude the possible play of qualitative factors; their intervention is, indeed, probable in specific cases, such as, *e. g.*, in the *Melissotarsus beccarii*, which I have described, and which has two kinds of workers of the same size but with heads of a different form.

"*The peculiarities in which the workers differ from the corresponding sexual forms are, therefore, not innate or blastogenic, but acquired, that is somatogenic.* Nor are they transmitted as such, but in the form of a peculiarity of the germ-plasm that enables this substance to take different developmental paths during the ontogeny. Such a peculiarity of the germ may be compared with the hereditary predisposition to certain diseases, which like hereditary myopia develop only under certain conditions. The eye of the congenitally myopic individual is blastogenetically predisposed to short-sightedness, but only becomes short-sighted when the accommodation apparatus of the eye has been overtaxed by continual exertion. Myopia arises, like the peculiarities of the worker ants, as a somatic affection on a blastogenic foundation.

"With this assumption the problem of the development of workers seems to me to become more intelligible and to be brought a step nearer its solution. The peculiarities of the Hymenoptera workers are laid down in every female egg; those of the termite workers in every egg of either sex, but they can only manifest themselves in the presence of specific vital conditions. In the phylogeny of the various species of ants the worker peculiarities are not transmitted but merely the faculty of all fertilized eggs to be reared as a single or several kinds of workers. The peculiar instinct of rearing workers

[1] Die Entstehung und Ausbildung des Arbeiterstandes bei den Ameisen. Biol. Centralbl., XIV, 1894, pp. 58, 59.

is also transmitted, since it must be exercised by the fertile females in establishing their colonies."[1]

In other words, Emery supposes that the germ-plasm of the social insects is characterized by a peculiar sensitivity which makes it amenable to the different influences to which it is subjected in the fostering environment of the colony. This view, as I shall endeavor to show in the concluding paragraphs of this article, is worthy of more attention than it has received. It was rejected by Weismann in his Romanes lecture on the ground that typical organs like the wings, ovarian tubules, spermatheca, etc. could not disappear from the worker by any ontogenetic, but only by a phylogenetic process, but his argument is based on what is known to occur in other animals and necessarily fails to apply to animals which, like the social Hymenoptera, seem to be unique in presenting the very conditions Emery has been trying to explain.

Wasmann[2] accepts Weismann's view of the determinants and the function of nutrition as a mere stimulus, but he rejects his view that natural selection alone can account for the adaptive structures and instincts of worker ants.

Forel in his 'Fournis de la Suisse' (p. 440, 441, *nota*) accepts the Darwinian view of the origin of the worker caste by natural selection acting on a primitive differentiation of the female into fertile and sterile forms in the sphere of instinct before definite morphological differentiation sets in. In a recent paper[3] he is inclined to side with Weismann and to lay considerable stress on the effects of natural selection and the struggle for existence in producing variation and polymorphism as opposed to the internal factors.

Escherich,[4] has given a valuable review of the subject of polymorphism among ants, without, however, clearly defining the general issues. His own view is apparently in complete accord with that of Weismann.

Marchal, as the result of his splendid work on the habits of the social wasps,[5] has given the following suggestive discussion of polymorphism along the lines suggested by Spencer and Emery: "At the beginning of the social state the infertility of the first brood of progeny produced by the mother gradually became established. This infertility was the result of the necessarily insufficient nourishment distributed by the queen among her too numerous offspring, and the eggs in the ovaries of the young females could not mature, first, because the reserve substances (adipose tissue)

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[1] For a fuller account of Emery's views, see his article 'Le Polymorphisme des Fourmis et la Castration Alimentaire.' Compt. Rend., 3me. Congr. Internat. Zool., Leyde (Sept. 1895), 1896, pp. 395–407.

[2] Die ergatogynen Formen, etc., *loc. cit.*, p. 638.

[3] Ueber Polymorphismus und Variation bei den Ameisen. Zool. Jahrb., Suppl., VII, 1904, pp. 571–586.

[4] Die Ameise. Schilderung ihrer Lebensweise. Braunschweig, 1906, pp. 45–54.

[5] La Reproduction et l' Evolution des Guêpes Sociales. Arch. Zoöl. Expér. et Gén., 3. ser., IV, 1896, pp. 1–100, 8 figs.

stored up in the larva were insufficient, and second, because immediately after hatching, the young females had to devote themselves to the care of the numerous larval colony, and especially to the *function of nursing*, which, as we have shown experimentally, prevents the maturation of the eggs. The mother being relieved of the care of feeding the larvæ and having over the workers the advantage of ovaries swollen with eggs, while the other females at the time of hatching contained only immature germs, continued to lay to the exclusion of the other females, whose nutricial functions kept them in a condition of sterility.

"At the end of the year, however, owing to the greater length of the imaginal than of the larval period, and also on account of the diminution in the egg laying of the queen or owing to her disappearance, the adult colony came to surpass the larval colony sufficiently in numbers to permit the later broods to receive and store up the reserve food which is indispensable to the maturation of the eggs. Hence these later broods alone would be able to hibernate and reproduce the species during the following spring. Only these individuals, therefore, should be regarded as representing the stirp from which all the future individuals proceed, the others being naturally eliminated from the genealogical tree.

"This single fact, namely, that only the individuals reared at the end of the season participate in the direct lineage of the different generations, suffices to account for a modification in the germ-plasm of the species; for *without even adducing the specific instinctive dispositions* which would later be acquired by natural selection, the conditions of nurture, and in particular those of nourishment, which control the development of the animal till the end of the year, depart from the mean of the variable conditions of nurture to which the evolving presocial insect was submitted. Under the influence of this modification acting as *external conditions*, constantly and always in the same manner, a new physicochemical constitution of the germ-plasm must necessarily arise and a new direction of development be opened up, namely, that which leads to the queen type.

"If the preceding theory be granted, the realization of the worker type becomes equally comprehensible. As long as there is no perceptible variation in the constitution of the germ-plasm, the worker will differ from the queen only in slight quantitative morphological variations, depending essentially, as we have demonstrated, on the phenomena of nutrition. This is the case in *Polistes* and less obviously in certain species of wasps (*Vespa*) which present an uninterrupted series of forms connecting the worker and queen types.

"But as soon as a perceptible modification of the germ-plasm intervenes, matters cease to be the same. The egg laid by a queen in the spring, like

all the eggs which she lays, contains, of course, this germ-plasm which has been modified by the autumnal régime and therefore presents all its modifications. Now the conditions under which it is called upon to pursue its development are not the same as those of the autumn, to which its germ-plasm has been exclusively habituated during a very long series of generations. This germ-plasm whose fixed constitution is adapted to a precise method of development in a given environment according to the queen type, and has been determined by the conditions to which it has been subjected for a great number of generations, finds itself in this particular egg suddenly emancipated from these modifying conditions and subjected to altogether new ones. What may we expect it to produce? If the modifications to which it finds itself submitted are too severe, it must perish; if, on the contrary, they are compatible with its evolution, it must proceed with its development as well as it can, like an animal constrained to develop under abnormal conditions. It is evident that the latter alternative alone is to be considered, since the former would lead to the extinction of the species. Now it is easy to see that this second alternative is nothing more nor less than a case of *experimental dichogeny.*"

In a later paper Marchal [1] aptly designates the suppression of the functional activity of the ovaries through the nursing, or nutricial habits of the workers as *nutricial castration.* He has shown that by eliminating the queen from the *Vespa* colony as many as a third of the workers become fertile. A similar result is brought about by a suppression or merely by a temporary suspension of the egg-laying of the queen. This can be due, as he maintains, only to abolition of the nursing function and the appropriation by the workers of the food which under normal conditions they would feed to the larvæ.

Marchal's view differs from that of Weismann in postulating a homogeneous germ-plasm and in rejecting representative units like the ids, determinants, etc. He regards the "differentiation" of the queen as due to the direct action of external conditions, especially of nourishment, and the differentiation of the workers as belonging to a class of phenomena, "which, if not essentially understood, are nevertheless known in their manifestations, namely *teratogenesis* and *dichogeny.*" Although this view is very similar to those of Spencer and Emery, the conception of nutricial castration seems to me to represent a valuable addition and I shall revert to it.[2]

[1] La Castration Nutricial chez les Hymenopterès Sociaux. Compt. Rend. Sec. Biol., 5 Juin 1897, 2 pp.

[2] Nutricial castration (from *nutrix*, a nurse) must be distinguished from 'alimentary castration' (Emery, Le Polymorphisme, etc., *loc. cit.*), although both are responsible for the infertility of the worker. Through alimentary castration the development of the reproductive organs is inhibited in the larva and pupa, and this inhibition is maintained in the adult by the strong

The various extracts above quoted show very clearly that previous authors have been impressed by very different aspects of the complicated phenomena of polymorphism, and that each author has emphasized the aspect which seemed the most promising from the standpoint of the general evolutionary theory he happened to be defending. Escherich has recently called attention to two very different ways of envisaging the problem; one of these is physiological and ontogenetic, the other ethological and phylogenetic. As these furnish convenient captions under which to continue the discussion of the subject, I shall adopt them, and conclude with a third, the psychological aspect, which is certainly of sufficient importance to deserve consideration.

3. The Ontogenetic and Physiological Aspects of Polymorphism.

While the ontogeny of nearly all animals is a repetition or reproduction of the ontogeny of the parent, this is usually not the case in the social Hymenoptera, since the majority of the fertilized eggs do not give rise to queens but to more or less aberrant organisms, the workers. And as these do not, as a rule, reproduce, the whole phenomenon is calculated to arouse the interest of both the physiologist and the embryologist. The former, concentrating his attention on the reactions of the animal to the stimuli proceeding from its environment, is inclined to study its later stages as determined by the reactions to such stimuli, without regard to any internal or hereditary predetermination or disposition, while the embryologist seeks out the earliest moment at which the organism may be shown to deviate from the ontogenetic pattern of its parent. If this moment can be detected very early in the development he will be inclined to project the morphological differentiation back into the germ-plasm and to regard the efforts of the physiologist as relatively unimportant if not altogether futile. Now in his study of the social insects the embryologist is at a serious disadvantage, since he is unable to distinguish any prospective worker or queen characters in the eggs or even in the young larvæ. Compelled, therefore, to restrict his investigations to the older larvæ, whose development as mere processes of histogenesis and metamorphosis throws little or no light on the meaning of polymorphism, he is bound to abdicate and leave the physiologist in possession of the problem.

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nursing instincts which prevent the workers from appropriating much of the food supply of the colony to their individual use. In many of the higher animals also (birds, mammals) reproduction is inhibited by the exercise of the nutricial function. A third method of inhibiting or destroying the reproductive function is known to occur in the ' parasitic castration ' of certain bees and wasps (*Andrena, Polistes*) by Strepsiptera (*Stylops, Xenos*, etc.). See Perez, Des Effets du Parasitisme des Stylops sur les Apiaires du Genre Andrena. Actes Soc. Linn. Bordeau., 1886, 40 pp. 2 pll. Westwood (Notice of the Occurrence of a Strepsipterous Insect Parasitic on Ants, discovered in Ceylon by J. Nietner, Trans. Ent. Soc. London (2), V, 1861, pp. 418–420) has also described a Strepsipteron (*Myrmecolax nietneri*) which in all probability produces this form of castration in certain Formicidæ.

The physiologist, in seeking to determine whether there is in the environment of the developing social Hymenopteron any normal stimulus that may account for the deviation towards the worker or queen type, can hardly overlook one of the most important of all stimuli, the food of the larva. At first sight this bids fair greatly to simplify the problem of polymorphism, for the mere size of the adult insect might seem to be attributable to the quantity, its morphological deviations to the quality of the food administered to it during its larval life. Closer examination of the subject, however, cannot fail to show that larval alimentation among such highly specialized animals as the social insects, and especially in the honey-bees and ants, where the differences between the queens and workers are most salient, is a subject of considerable complexity. In the first place it is evident that it is not the food administered that acts as a stimulus but the portion of it that is assimilated by the living tissues of the larva. In other words, the larva is not altogether a passive organism, compelled to utilize all the food that is forced upon it, but an active agent capable, at least to a certain extent, of determining its own development. And the physiologist might have difficulty in meeting the assertion, that the larva utilizes only those portions of the proffered food which are most conducive to the specific predetermined trend of its development. In the second place, while experiments on many organisms have shown that the quantity of assimilated food may produce great changes in size or stature, there is practically nothing to show that even very great differences in the quality of the food can bring about morphological differences of such magnitude as those which separate the queens and workers of many ants.[1]

These more general considerations are reinforced by the following inferences from the known facts of larval feeding:

1. There seems to be no valid reason for supposing that the morphogeny of the queens of the social Hymenoptera depends on a particular diet, since with the possible exception of the honey and stingless bees, to be considered presently, they differ in no essential respect from the corresponding sexual phase of the solitary species. In both cases they are the normal females of the species and bear the same morphological relations to their males quite irrespective of the nature of their larval food. Hence, with the above mentioned exception of the honey and stingless bees, the question of the morphogenic value of the larval food may be restricted to the worker forms.

2. Observation shows that although the food administered to the

[1] Emery (Le Polymorphisme, etc., *loc. cit.*) has called attention to the importance of the assimilative powers of the ant larva itself, quite irrespective of the quantity and quality of the food administered by the nurses — a very obscure physiological phenomenon, but not without analogies in other animals and especially in plants, which may assume a dwarfed habitus under apparently very favorable trophic conditions. The production of 'high' and 'low' males in Scarabæid and Lucanid beetles seems to be of the same nature.

larvæ of the various social insects is often very different in its nature, even in closely related species, the structure of the workers may be extremely uniform and exhibit only slight specific differences. Among ants alone we find the larvæ fed with a great variety of substances. Thus the Attii feed their larvæ on fungus hyphæ, the harvesting species of *Pheidole, Pogonomyrmex,* etc., on seeds, the Ponerinæ and many Myrmicinæ on pieces of insects, and most Dolichoderinæ and Camponotinæ supply their young with regurgitated liquid food. According to Dahl,[1] the larvæ of at least one species (*Camponotus quadriceps*) feed on the pith of plants. The quality of the food itself cannot, therefore, be supposed to have a morphogenic value. And even if we admit what seems to be very probable, namely, that a salivary secretion — possibly containing an enzyme — may be administered by some of these ants at least to their younger larvæ, the case against the morphogenic effects of qualitative feeding is not materially altered, as we see from the following considerations:

3. In incipient ant-colonies the queen mother takes no food often for as long a period as eight or nine months, and during all this time is compelled to feed her first brood of larvæ exclusively on the secretions of her salivary glands. This diet, which is purely qualitative, though very limited in quantity, produces only workers and these of an extremely small size (micrergates).

4. In the honey-bees, on the other hand, qualitative feeding, namely with a secretion, the so-called "royal jelly," which according to some authors (Schiemenz) is derived from the salivary glands, according to others (Planta) from the clylific stomach of the nurses, does not produce workers but queens. In this case, however, the food is administered in considerable quantity, since it is not provided by a single starving mother, as in the case of the ants, but by a host of vigorous and well-fed nurses. Although it has been taken for granted that the fertilized egg of the honey-bee becomes a queen as the result of this peculiar diet, the matter appears in a different light when it is considered in connection with von Ihering's recent observations on the stingless bees (Meliponidæ) of South America.[2] He has shown that in the species of *Melipona* the cells in which the males, queens, and workers are reared are all of the same size. These cells are provisioned with the same kind of food (honey and pollen) and an egg is laid in each. Thereupon they are sealed up, and although the larvæ are not fed from day to day as in the honey-bees, but like those of the solitary bees subsist on stored provisions, this uniform treatment nevertheless results in the production of

[1] Das Leben der Ameisen im Bismarck-Archipel, Friedländer u. Sohn, 1901, p. 31.
[2] Biologie der stachellosen Honigbienen Brasiliens. Zool. Jahrb., Abth. f. Syst., XIX, 1903, pp. 179–287, 13 pll., 8 text-figs.

three sharply differentiated castes. On hatching the queen *Melipona* has very small ovaries with immature eggs, but in the allied genus *Trigona*, the species of which differ from the *Meliponæ* in constructing large queen cells and in storing them with a greater quantity of honey and pollen, the queen hatches with her ovaries full of ripe eggs. These facts indicate that the large size of the queen cell and its greater store of provisions are merely adaptations for accelerating the development of the ovaries. Now on reverting to the honey-bee we may adopt a similar explanation for the feeding of the queen larva with a special secretion like the "royal jelly." As is well known, the queen honey-bee hatches in about sixteen days from the time the egg is laid, while the worker, though a smaller insect and possessing imperfect ovaries, requires four or five days longer to complete her development. That the special feeding of the queen larva is merely an adaptation for accelerating the development of the ovaries is also indicated by the fact that this insect is able to lay within ten days from the date of hatching.[1] If this interpretation is correct the qualitative feeding of the queen larva is not primarily a morphogenic but a growth stimulus.

5. The grossly mechanical withdrawal of food substances already assimilated by the larva, as in the case of the *Pheidole instabilis* parasitized by the *Orasema* described in the first part of this article, produces changes of the same kind as those which distinguish the worker ant from the queen, *i. e.*, microcephaly, microphthalmy, stenonoty, and aptery. This case is of unusual interest because the semipupa, after the detachment of the parasite, seems to undergo a kind of regeneration and produces a small but harmonious whole out of the depleted formative substances at its disposal. What is certainly a female or soldier semipupa takes on worker characters while the worker semipupa may be said to become infra-ergatoid as the result of the sudden loss of formative substances. These observations clearly indicate that the normal worker traits may be the result of starvation or withholding of food rather than the administration of a particular diet.

6. The pseudogynes of *Formica* admit of a similar interpretation if it be true, as I have maintained (p. 33) that they arise from starved female larvæ. Here, too, the organism undergoes a kind of regeneration or regulation and assumes the worker aspect owing to a dearth of sufficient formative substances with which to complete the development as originally planned.

[1] Cheshire (Bees and Bee-keeping. Scientific and Practical, 2 vols.) gives a different interpretation of the rapid growth of the queens. On p. 244, Vol. I, he regards the acceleration as the result of selection, since the first queen to hatch destroys her unhatched sisters. Hence the more rapidly the insect develops the greater her chances of survival. In another place (Vol. II, pp. 320, 321), however, he regards this individual advantage as a social disadvantage, since the toleration of several queens would greatly increase the number of workers and thereby strengthen the colony. My view refers not so much to the acceleration of the development of the queen as to that of her ovaries. It is evident that this, too, may be expressed in terms of advantage to the colony, since it enables the queen to lay very soon after the marriage flight.

7. In the preceding cases, as I have shown in the first part of this article, the ants undergo a peculiar structural modification as the result of tolerating parasites that bring about unusual perturbations in the trophic status of the colony. When ants themselves become parasitic on other ants a similar perturbation results, but in these cases the morphological effects are confined to the parasitic species and do not extend to their hosts. This must be attributed to the fact that the parasitizing species live in affluence and are no longer required to take part in the arduous and exacting labors of the colony. Under such circumstances the inhibitory effects of nutricial castration on the development of the ovaries of the workers are removed and there is a tendency for this caste to be replaced by egg-laying, gynæcoid individuals or by ergatogynes, or for it to disappear completely. These effects are clearly visible in nearly all parasitic ants. In the European *Tomognathus sublævis*, for example, the only known females are gynæcoid workers. In the American *Leptothorax emersoni*, as I have shown,[1] gynæcoid workers and ergatogynes are unusually abundant while the true females seem to be on the verge of disappearing. Among the typical amazon ants (*Polyergus rufescens*) of Europe, ergatogynes are not uncommon. In *Strongylognathus testaceus* the worker caste seems to be dwindling, while in several permanently parasitic genera (*Anergates, Wheeleria, Epœcus, Epipheidole* and *Sympheidole*) it has completely disappeared. Only one cause can be assigned to these remarkable effects — the abundance of food with which the parasites are provided by their hosts.

8. In the Ponerinæ and certain Myrmicinæ, like *Pheidole, Pogonomyrmex,* and *Aphænogaster,* the larvæ are fed on pieces of insects or seeds, the exact assimilative value of which as food can neither be determined nor controlled by the nurses. And while they may perhaps regulate the quantity of food administered, it is more probable that this must fluctuate within limits so wide and indefinite as to fail altogether to account for the uniform and precise morphological results that we witness in the personnel of the various colonies. Moreover, accurate determination of the food supply by the workers must be quite impossible in cases like that of the *Pachycondyla* larva attended by the commensal *Metopina* which surreptitiously consumes a portion of the proferred food.

9. The intimate dependence of the appearance of the different castes of the social insects on the seasons may also be adduced as evidence of the direct effects of the food supply in producing workers and queens. The latter are reared only when the trophic condition of the colony is most favorable and this coincides with the summer months. In the great major-

[1] Ethological Observations on an American Ant (Lepthorax Emersoni Wheeler), Arch. f. Psych. u. Neurol., II, 1903, p. 6.

ity of species only workers and males are produced at other seasons. Here, too, the cause is to be sought in the deficient quantity of food rather than in its quality, which is, in all probability, the same throughout the year, especially in such ants as the fungus-growing Attii and the seed storing Myrmicinæ.

While these considerations tend to invalidate the supposition that qualitative feeding is responsible for the morphological peculiarities of the worker type, they are less equivocal in regard to the morphogenic effects of quantitative feeding. Indeed, several of the observations above cited show very clearly that diminution in stature and, in pathological cases, even reversion to the worker form may be the direct effect of underfeeding. To the same cause we may confidently assign several of the atypical phases among ants, such as the micrergates, microgynes, and micranērs, just as we may regard the macrergates, macrogynes, and macranērs as due to overfeeding. These are, of course, cases of nanism and giantism, variations in stature, not in form. Similarly, all cases in which, as in certain species of *Formica, Camponotus, Pheidole,* etc., the workers or desmergates vary in size, must be regarded as the result of variable quantitative feeding in the larval stage. Here we are confronted with the same conditions as Weismann observed in the blow-flies and which entomologists have noticed in many other insects. Such variations are of the fluctuating type and are therefore attributable to the direct effects of the environment. The soldier and worker, however, differ from the queen in the absence of certain characters, like the wings, wing-muscles, spermatheca, some of the ovarian tubules, etc., and the presence of other characters, like the peculiar shape of the head and mandibles. In these respects the sterile castes may be regarded as mutants, and Weismann's contention that such characters cannot be produced by external conditions, such as feeding, is in full accord with de Vries's hypothesis. His further contention, however, that they must therefore be produced by natural selection need not detain us, since it is daily becoming more and more evident that this is not a creative but an eliminative principle. It is certain that the very plastic social insects, like the ants, have developed a type of ontogeny which enables them not only to pupate at an extremely early period of larval life, but also to hatch and survive as useful though highly specialized members of the colony. It is quite conceivable that this precocious pupation may be directly responsible for the complete suppression of certain organs that require for their formation more substance than the underfed larva has been able to accumulate. At the same time it must be admitted that a direct causal connection between underfeeding on the one hand and the ontogenetic loss or development of characters on the other, has not been satisfactorily established. The conditions in the termites,

which are often cited as furnishing proof of this connection, are even more complicated and obscure than those of the social Hymenoptera. While Grassi and Sandias,[1] and Silvestri,[2] agree with Spencer in regarding the feeding as the direct cause of the production of the various castes, Herbst,[3] who has reviewed the work of the former authors, shows that their observations are by no means conclusive; and Heath[4] makes the following statement in regard to his experiments on Californian termites: "For months I have fed a large number of termite colonies of all ages, with or without royal pairs, on various kinds and amounts of food — proctodæal food dissected from workers or in other cases from royal forms, stomodæal food from the same sources, sawdust to which different nutritious ingredients had been added — but in spite of all I cannot feel perfectly sure that I have influenced in any unusual way the growth of a single individual."

This rather unsatisfactory answer to the question as to whether quantity or quality of food or both, have an ergatomorphic value, has led some investigators to seek a solution along more indirect lines. Thus O. Hertwig and Herbst suggest that the morphogenic stimulus may be furnished by some internal secretion of the reproductive organs. This, too, is possible, but owing to our very imperfect knowledge of the internal secretions, even in the higher animals, we are not in a position either to accept or reject this suggestion.

More tangible is Emery's attempt[5] to explain the worker characters as the result of a struggle among the parts of a prematurely metamorphosing insect. He has not been led into the invisible battle of the ids and determinants on which Weismann recently constructed his hypothesis of germinal selection,[6] but is content with a struggle between the larger regions of the body and between their various organs. This point of view was suggested by his study of the mermithergates. He is of the opinion that "the same law of growth which determines the proportions of the head and gaster in the *Mermis*-infested workers (see pp. 24, 25 *antea*) obtains also in normal ants. I designate it as the "law of opposition between head and gaster" and would state it as follows:

"While the imago is developing within the full-grown ant larva, what is needful for the structures essential to the life of the organism is first emphasized, especially for the digestive and reproductive organs contained in the gaster; the formation of the external shape of the head, and especially of

[1] Costituzione e Sviluppo della Società dei Termitidi. Catania, 1893, 150 pp., 5 pll.
[2] Operai ginecoidi di Termes, con osservazioni intorno l' origine delle varie caste nei Termitidi, Real. Accad. Lincei, X, sér. 5, 1901, pp. 479–484.
[3] Formative Reize in der Tierischen Ontogenese, Leipzig, Arthur Georgi, 1901, pp. 20–24.
[4] The Habits of California Termites. Biol Bull. IV, Dec. 1902, pp. 62–23.
[5] Zur Kenntniss des Polymorphismus, etc., *loc. cit.*, p. 603.
[6] On Germinal Selection. Religion of Science Library. Open Court Publ. Co., Chicago, 1896.

the mandibles and of the muscles which are to move them, is regulated according to the amount of formative substance remaining. Perhaps phylogenetic factors also enter into this process and, with the absence of sufficient substance, also phenomena of atavism in the form of a certain stress on the phylogenetically older structures.

"As a result of these processes we find that when one of two metamorphosing larvæ has a large abdomen its head will be relatively smaller than that of the other, because there remains a relatively smaller amount of larval food substance."

Towards the end of his paper (pp. 608, 609) Emery still further elaborates this view and concludes with the following remarks: "The determination both of the relative size of the various regions of the body and of the individual organs to one another may be regarded as a struggle among the parts (Kampf der Theile) of the organism. In the metabolic insects, in particular, this struggle may be divided into two periods:

"During the first period, which may be of long duration, food supplies are accumulated in an indifferent manner as the larval fat-body while at the same time the rudiments of the imaginal organs arise and prepare themselves for the struggle.

"During the second period the struggle among the rudiments actually sets in and must be particularly acute in cases where the store of food is meager on account of underfeeding of the larva. The struggle will be decided in favor of the rudiments which are capable of most vigorously appropriating the nourishment.

"To this struggle is due the regular type of polymorphism as it is exhibited by worker ants in its definite relations to the volume of the body. But before this struggle takes place, the result is already decided, because the ability of the individual imaginal rudiments to attract the larval food reserves has been determined. We may therefore assume that during the first period, by a process still completely unknown, there is a determination of the growth energy of the individual imaginal rudiments which, in the second period, will struggle for the possession of the limited supply of larval food. We may further assume that during the first period, through the relations of the imaginal rudiments to one another and to the amount of larval food substances, the type of the individual, whether female, worker, pseudogyne, etc., as well as its size, is determined. These peculiarities, however, do not manifest themselves till the second period.

"*As trophic polymorphism the polymorphism of the female sex in ants is a function of the distribution of the nutritive substances accumulated during larval life, a distribution which in turn is determined by the struggle among the imaginal rudiments.*"

In commenting on this hypothesis of a struggle of the parts in connection with the mermithergates, I have already shown (p. 26) that it is inapplicable to the cases which first suggested it. This does not, however, disqualify it as a possible explanation of the normal worker forms. It does, indeed, appear to give us an insight into the possible conditions of development in the starved larvæ from which the workers arise and suggests interesting problems for the experimentalist. Still it is incomplete and like the other views considered in the preceding paragraphs, fails to account for the highly adaptive structure of the worker.

There lurks, perhaps, in Emery's hypothesis a suggestion of a widespread notion that there is something monstrous, teratological or hypertelic, about the workers and especially about the soldiers of the social insects. This is more explicitly stated in the above-quoted passages from Spencer and Marchal (pp. 60, 65). The latter, in fact, regards the rearing of the sterile forms as a kind of experimental teratogeny. Such an impression is very natural, for the soldiers of many ants and termites certainly exhibit developments of the head and mandibles unlike anything found in other insects. And it is not impossible that these castes may have orginally made their appearance as teratological developments. But that they are such at the present time is very improbable, since we find that they are not only normal and all-important constituents of the colony, but have become exquisitely adapted to particular functions. Wherever the habits of the soldiers have been carefully studied it has been found that their singular and apparently hypertrophied structures have a very definite function. Thus it has been shown that the peculiarly truncated heads of the *Colobopsis* soldiers are used as "animated front-doors" in closing the circular entrances to the galleries of the nest, that the colossal crania of the *Pheidole* soldiers accommodate the huge muscle-masses of the jaws which in turn are used in cracking hard seeds and the tough integument of insects, and that the peculiar sickle-shaped mandibles of the soldiers of *Myrmecocystus bombycinus* are used for carrying the voluminous pupæ.[1] It is very probable that in termites the singular heads of the nasute and mandibulate soldiers will be found to be similarly adapted to special functions in the economy of the colony. At any rate we are not justified in regarding such structures as hypertelic or teratological till we know more about the habits of the species in which they occur.

We may conclude, therefore, that while the conception of the worker type as the result of imperfect nutrition is supported by a considerable volume of evidence, we are still unable to understand how this result can take

[1] See Escherich, Die Ameise, *loc. cit.*, p. 46.

on so highly adaptive a character. Such a concise effect can hardly be due to manifold and fluctuating external causes like nutrition, but must proceed from some more deeply seated cause within the organism itself. Of course, the difficulty here encountered is by no means peculiar to polymorphism; it confronts us at every turn as the all-pervading enigma of living matter. Whether we shall fare better by approaching the subject from a different point of departure remains to be seen.

4. The Phylogenetic Aspect of Polymorphism.

An intensive study of the structure and habits of ants must inevitably lead to a certain amount of speculation concerning the phylogenetic development of their colonies. That these insects have had communistic habits for ages is clearly indicated by the fact that all of the numerous existing species are eminently social. There can be little doubt, however, that they arose from forms with habits not unlike those we find today in some of the solitary wasps, such as the Bembecidæ, or in the remarkable South African bees of the genus *Allodape*.[1] Unlike other solitary wasps, the females of *Bembex* may be said to be incipiently social, since a number of them choose a nesting site in common and, though each has her own burrow, coöperate with one another in driving away intruders. *Bembex* has also taken an important step in the direction of the social wasps not only in surviving the hatching of her larvæ, but also in visiting them from day to day for the purpose of providing them with fresh insect food.[2]

At a very early period the ants and social wasps must have made a further advance when the mother insect succeeded in surviving till after her progeny had completed their development. This seems to have led naturally to a stage in which the young females remained with their mother and reared their progeny in the parental nest, thus constituting a colony of a number of similar fertile females with a common and indiscriminate interest in the brood. This colony, after growing to a certain size, became unstable in the same way as any aggregate of like units, and must soon have shown a differentiation of its members into two classes, one of individuals devoted to reproduction and another class devoted to alimentation and protection. In this division of labor only the latter class underwent important somatic modification and specialization, while the former retained its prim-

[1] I infer this from a brief account (*in litteris*) of two species of these insects, recently received, together with specimens of their extraordinary larvæ, from Dr. Hans Brauns of Cape Colony.

[2] Interesting accounts of the habits of this insect have been published by Fabre (Souvenirs Entomologiques. Prem. Sér., Paris, Chas. Delagrave, 1 éd., 1879; 3 éd., 1894, pp. 221–234); Wesenberg-Lund (Bembex rostrata, dens Liv og Instinkter. Ent. Meddel. Kjöbenhavn, III, 1891, pp. 19–44; English résumé in Psyche, VII, p. 62); and Geo. W. and Elizabeth G. Peckham, On the Instincts and Habits of the Solitary Wasps. Wis. Geol. Nat. Hist. Surv., Bull. No. 2, 1898, pp. 58–72.

itive and more generalized characters. It is more than probable, as I shall attempt to show in the sequel, that this differentiation was manifested in the sphere of instinct long before it assumed morphological expression. The social wasps and bumble bees are practically still in this stage of sociogeny. The ants, however, have specialized and refined on these conditions till they not only have a single marked alimentative and protective caste without wings[1] and lacking many other female characters, but also in some species two distinct castes with a corresponding further division of labor. Both in the phylogeny and the ontogeny these characters appear as the result of nutricial castration.

If the foregoing considerations be granted the biogenetic law may be said to hold good in the sociogeny of the ants, for the actual ontogenetic development of their colonies conforms not only to the purely conjectural requirements of phylogeny but also with the stages represented by the various extant groups of social insects. It is clear that we cannot include the honey-bee among these groups, since this insect is demonstrably so aberrant that it is difficult to compare it with the other social insects.

Comparison of the different genera and subfamilies of ants among themselves shows that some of them have retained a very primitive social organization, and with it a relatively incomplete polymorphism, whereas others have a much more highly developed social life and a greater differentiation of the castes. Such a comparison coupled with a study of the natural relationships of the various genera as displayed in structure, shows very clearly that the advance from generalized to highly specialized societies did not follow a single upward course during the phylogeny, but occurred repeatedly and in different phyletic groups. And since the complications of polymorphism kept pace with those of social organization, we may say that the differentiation of the originally single worker caste into dinergates, or soldiers on the one hand and micrergates, or small workers, on the other,

[1] Emery (Zur Kenntniss des Polymorphismus, etc., *loc. cit.*, pp. 628, 629) has recently restated his opinion that the females of the primitive ants were wingless, like the workers of existing species, and acquired wings during the phylogeny, an opinion to which he was led by deriving the ants from Mutillid-like ancestors. McClendon and I (Dimorphic Queens, etc., *loc. cit.*, p. 161, 162) dissented from this view on the ground that there is no known case among insects of a reacquisition after loss of these organs. Emery replies that they have not been lost but still exist in the germ-plasm of the female Mutillid, since she produces males with perfect wings. He believes that the wings of existing female ants are an inheritance from the male. The possibility of such an inheritance cannot, of course, be disputed, but when the matter is so largely conjectural, the simpler hypothesis maintained by McClendon and myself seems preferable. It is certainly easier to believe that both Mutillids and ants are derived from a common ancestor with both sexes winged, and that the wings were retained by the worker ants, as they are still in the social bees and wasps, till these castes had been definitely established, than to assume a loss followed by a reacquisition of these organs in the queens. Moreover, there is no known case in which an organ has been completely transferred to the opposite sex. Even cases like the vestigial mammæ of mammals and the antlers of the female reindeer are best explained as characters once equally developed and functional in both sexes. (See Lydekker, The Deer of all Lands, London, Rowland Ward, 1898, p. 10). The ergatoid and gynæcoid characters of male ants referred to by Emery, may indeed be inherited from the workers and females respectively, but they are modifications of well-developed and functional organs of the male. This case is therefore not strictly comparable with the transfer of whole organs like the wings with their complicated musculature, venation, etc., from one sex to the other.

has been repeated in remotely related genera. In some genera (*Stenamma* sens. str., *Leptothorax*) there are also indications of a lapsing of highly specialized into simpler conditions by a kind of social degeneration. In its extreme form this manifests itself as a suppression of castes and a consequent simplification of polymorphism. Beautiful illustrations of this statement are furnished by the parasitic species that have lost their worker caste. But there are also cases in which the queen caste has been suppressed and its functions usurped by workers.

Not only have these greater changes been effected and fixed during the phylogenetic history of the Formicidæ, but also many subtler differences such as those of stature, coloration, pilosity and sculpture. And although such differences belong to the class of fluctuating variations and are usually supposed to have a greater ontogenetic than phylogenetic significance, they are undoubtedly of great antiquity and must therefore be regarded as more important than many of the minor morphological traits.

Emery was the first to call attention to a number of peculiar phylogenetic stages in the development of stature among ants.[1] We find by comparison with the male, which may be regarded as a relatively stable and conservative form, that the cospecific females and workers may vary in stature independently of each other. The following are the stages recognized by Emery, with some additions of my own:

1. In the earliest phylogenetic condition which is still preserved in the ants of the subfamily Ponerinæ and in certain Myrmicinæ (*Pseudomyrma, Myrmecina*, etc.), the workers are monomorphic and of about the same size as the males and females.

2. The worker becomes highly variable in stature from large forms (dinergates, or maxima workers) resembling the female, through a series of intermediates (desmergates) to very small forms (minima workers, or micrergates). This condition obtains in the Dorylinæ, some Myrmicinæ, (some species of *Pheidole, Pheidologeton, Atta*), Camponotinæ (*Camponotus*) and Dolichoderinæ (*Azteca*).

3. The worker becomes dimorphic through the disappearance of the desmergates, so that the originally single, variable caste is now represented by two, the soldier (dinergate) and worker proper. We find this condition in certain Myrmicinæ and Camponotinæ (*Cryptocerus, Pheidole, Acanthomyrmex, Colobopsis*, etc.).

4. The soldier of the preceding stage disappears completely, so that the worker caste again becomes monomorphic but is represented by individuals very much smaller than the female. Such individuals are really micrergates.

[1] Die Entstehung und Ausbildung der Arbeiter bei den Ameisen, *loc. cit.*, pp. 55, 56.

This condition is seen in certain Myrmicine genera, especially of the tribe Solenopsidii (*Carebara, Erebomyrma, Diplomorium,* most species of *Solenopsis,* etc.).

5. The worker form disappears completely, leaving only the males and females to represent the species, which thus returns to the condition of sexual dimorphism seen in the great majority of insects and other Metazoa. This occurs in the parasitic ants of the genera *Anergates, Wheeleria, Epœcus, Sympheidole* and *Epipheidole.*

6. In certain species the workers remain stationary while the female increases in size. This is indicated by the fact that the worker and male have approximately the same stature. Such a condition obtains in certain Myrmicinæ (*Cremastogaster*), Camponotinæ (*Lasius, Prenolepis, Brachymyrmex,* the North American species of *Myrmecocystus*), and Dolichoderinæ (*Iridomyrmex, Dorymyrmex, Liometopum*).

7. The worker caste remains stationary while the female diminishes in size till it may become even smaller than the large workers. This occurs in certain parasitic species of North America, like *Aphœnogaster tennesseensis* among the Myrmicinæ, and among the Camponotinæ in the species of the *Formica microgyna* group (*F. difficilis, nevadensis, impexa, montigena, nepticula*).

8. The female phase disappears completely and is replaced by a fertile, or gynæcoid worker form. This occurs in the Myrmicine *Tomognathus sublævis,* in certain Ponerine genera like *Leptogenys* (including the subgenus *Lobopelta*), and probably also in *Diacamma* and *Champsomyrmex.* The conditions in *Acanthostichus* and certain Cerapachyi (*Parasyscia peringueyi*) indicate that the dichthadiigynes of the Dorylinæ may have arisen from such gynæcoid workers instead of from winged queens.

9. The female shows a differentiation into two forms (α- and β-females) characterized by differences in the structure of the legs and antennæ, in pilosity and coloration (*Lasius latipes*), or in the length of the wings (macropterous and micropterous females of *L. niger*). The macrocephalic and microcephalic females of *Camponotus abdominalis* and *confusus* described by Emery[1] may also be regarded as α- and β-forms. In this series of stages, one to five represent changes in the worker caste while the female remains relatively stationary, whereas stages six to nine represent the converse conditions. Stages one to four probably succeeded one another in the order given, but stage five may have arisen either from the first or fourth. The sixth to ninth stages must, of course, be supposed to have developed independently of one another.

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[1] Le Polymorphisme des Fourmis, etc., *loc. cit.*, pp. 400, 401.

The stature differences described in the above paragraphs are in most if not all cases, highly adaptive. This is clearly seen in such forms as the Indo-African *Carebara,* the huge, deeply colored females of which are more than a thousand times as large as the diminutive, yellow workers. This ant dwells in termite nests where it occupies chambers connected by means of tenuous galleries with the spacious apartments of its hosts. The termites constitute a supply of food so accessible and abundant that the workers are able to rear enormous males and females, while they themselves must preserve their diminutive stature in adaptation to their clandestine and thievish habits. Similar conditions are found in many species of the allied genus *Solenopsis,* which inhabit delicate galleries communicating with the nests of other ants on the larvæ and pupæ of which they feed. In one species of this genus (*S. geminata*) however, which leads an independent life and feeds on miscellaneous insects and seeds, the worker caste is still highly polymorphic.

Another interesting case of adaptation in stature is seen in the ants of the *Formica microgyna* group. The females of these species are temporarily parasitic in the nests of other *Formicæ* and are therefore relieved of the labor of digging nests for themselves and rearing their first brood of larvæ. On this account they need not store up large quantities of food, so that the nourishment which in nonparasitic species goes to produce a comparatively few large females may be applied to the production of a large number of small females. This latter condition is necessary in parasitic species which are decimated by many vicissitudes before they can establish themselves successfully among alien hosts. I have already emphasized the adaptive significance of the disappearance of the worker caste among permanently parasitic species like *Anergates, Wheeleria,* etc.

There are several cases in which the worker and female differ greatly in color, pilosity, or sculpture, and in such cases either caste may be conservative or aberrant according to ethological requirements. Thus in certain temporary parasites like *Formica ciliata, oreas, montigena, dakotensis,* and *difficilis,* the female is aberrant in one or more of the characters mentioned, while the cospecific worker retains the ancestral characters of the same caste in the closely allied forms of *F. rufa.* The same condition is seen in a very different ant, *Aphœnogaster tennesseensis,* as the result of similar parasitic habits. In all of these species the females alone have developed myrmecophilous characters, like the long yellow hairs of *F. ciliata,* or the mimetic coloring of *F. difficilis,* which enable them to foist themselves on allied species and thus avoid the exhausting labor of excavating nests and rearing workers.

The foregoing observations indicate that in their morphological charac-

ters the worker and female of the same species have advanced or digressed in their phylogeny, remained stationary or retrograded, independently of each other. The same peculiarity is also observable in species with distinct worker and soldier castes. It thus becomes impossible even in closely related species of certain genera, like *Pheidole*, to predict the characters of the worker from a study of the cospecific soldier or *vice versâ*. And while adaptive characters in stature, sculpture, pilosity and color must depend for their ontogenetic development on the nourishment of the larvæ, it is equally certain that they have been acquired and fixed during the phylogeny of the species. In other words, nourishment, temperature, and other environmental factors merely furnish the conditions for the attainment of characters predetermined by heredity. We are therefore compelled to agree with Weismann that the characters that enable us to differentiate the castes must be represented in the egg. We may grant this, however, without accepting his conception of representative units, a conception which has been so often refuted that it is unnecessary to reconsider it in this connection. Far preferable appears to be the view of the constantly increasing number of biologists who conceive the adult characters to be represented in the germ as dynamic potencies or tensions rather than as morphological or chemical determinants.

Having touched upon this broader problem of heredity it will be necessary to say something about the inheritance or non-inheritance of acquired characters, especially as Weismann and his followers regard the social insects as demonstrating the non-transmissibility of somatogenic traits. In establishing this view and the all-sufficiency of natural selection to which it leads, Weismann seems to me to have slurred over the facts. While he admits that the workers may lay eggs, and that these may produce male offspring capable of fertilizing females, he nevertheless insists that this is altogether too infrequent to influence the germ-plasm of the species. I venture to maintain, on the contrary, that fertile workers occur much more frequently in all groups of social insects than has been generally supposed. As this fertility is merely a physiological state it has been often overlooked. Marchal (*vide ante*, p. 65), has shown how readily the workers of the social wasps assume this state, and the same is true of honey bees, especially of certain races like the Egyptians and Cyprians (*Apis mellifica-fasciata* and *cypria*). In the hives of these insects fertile workers are either always present or make their appearance within a few days after the removal of the queen. In the termites fertile soldiers have been observed by Grassi and Sandias (*l. c.*), and fertile workers by Silvestri (*l. c.*). Among ants fertile, or gynæcoid, workers occur so frequently as to lead to the belief that they must be present in all populous colonies. Their presence is also

proved by the production of considerable numbers of males in old and queenless colonies. In artificial nests Wasmann,[1] Miss Fielde[2] and myself have found egg-laying workers in abundance.

As the males that develop from worker eggs are perfectly normal, and in all probability as capable of mating as those derived from the eggs of queens, we are bound to conclude, especially if we adopt the theory of heredity advocated by Weismann himself, that the characters of the mother (in this case the worker) may secure representation in the germ-plasm of the species. Weismann is hardly consistent in denying the probability of such representation, for when he is bent on elaborating the imaginary structure of the germ-plasm he makes this substance singularly retentive of alteration by amphimixis, but when he is looking for facts to support the all-sufficiency of natural selection the germ-plasm becomes remarkably difficult of modification by anything except this eliminative factor. Certainly the simplest and directest method of securing a representation of the worker characters in the germ-plasm would be to get them from the worker itself that has survived in the struggle for existence, rather than through the action of natural selection on fortuitous constellations of determinants in the germ-plasm of the queen.

If we grant the possibility of a periodical influx of worker germ-plasm into that of the species, the transmission of characters acquired by this caste is no more impossible than it is in other animals, and the social insects should no longer be cited as furnishing conclusive proof of Weismannism. Weismann undoubtedly deserves lasting credit for his accurate distinction of blastogenic and somatogenic characters, and for having rid biological science of a multitude of crude conceptions concerning the inheritance of the latter. Even the many investigators, who, like Boveri,[3] Delage,[4] Pauly,[5] Plate,[6] Rignano,[7] and Semon,[8] still believe in the transmissibility of acquired characters, show the effects of Weismann's clarifying and critical efforts.

Plate[9] attempts to overcome the difficulties presented by the normal sterility of the worker by supposing that the distinguishing characters of this caste arose prior to their inability to reproduce. He recognizes the following stages in the phylogeny of the social insects:

"1. The presocial stage with but a single kind of male and female.

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[1] Parthenogensis bei Ameisen durch Künstliche Temperaturverhältnisse. Biol. Centralbl., XI, 1891, pp. 21–23.

[2] Observations on the Progeny of Virgin Ants. Biol. Bull., IX, 1905, pp. 355–360; Temperature as a Factor in the development of Ants, *ibid.*, IX, 1905, pp. 361–367.

[3] Die Organismen als Historische Wesen. Wurzburg, 1906.

[4] L' Hérédité et les Grands Problèmes de la Biologie Générale. 2 ed., Paris, C. Reinwald, 1903.

[5] Darwinismus und Lamarckismus. München, Ernest Reinhardt, 1905.

[6] Ueber die Bedeutung des Darwin'schen Selectionsprincips und Probleme der Artbildung. 2 Aufl., Leipzig, Wilh Engelmann, 1903.

[7] Sur la Transmissibilité des Charactères Acquis. Paris, Felix Alcan, 1906.

[8] Die Mneme als Erhaltendes Prinzip im Wechsel des Organischen Geschehens. Leipzig, Wilh. Engelmann, 1904.

[9] Ueber die Bedeutung des Darwins'schen Selectionsprincips, etc., *loc. cit.*, p. 73–75.

"2. The social stage with but a single kind of male and female. The peculiarities in nesting, caring for the brood, and the other instincts were already developed during this stage.

"3. The social stage with one kind of male and two or several kinds of females, which were all fertile, but in consequence of the physiological division of labor became more and more different in the course of generations. The division of labor took place in such a manner that the sexual functions passed over primarily to a group A, while the construction of the nest, predatory expeditions and other duties devolved mainly on another group of individuals (B) which on that account used their reproductive organs less and less.

"4. The present stage with one kind of male, a fertile form of female, which arose from group A, and one or several kinds of sterile females, or workers (group B).

He thus assumes that the differentiation into sterile and fertile forms did not take place till stage 3, and, if I understand him correctly, not till after "the races had become differentiated morphologically." This view, as Plate admits, resembles Spencer's (p. 59). The two views, in fact, differ merely in degree, for the underlying contention is the same, namely that sterility is one of the most recently developed characters among the social insects. There can be little doubt, however, that the smaller adaptive characters, for example those of the females of certain *Formicæ* above mentioned, must have made their appearance in the fourth stage of Plate's scheme. The view which I have advocated differs from Plate's in admitting that even in this stage the workers are fertile with sufficient frequency to maintain a representation of their characters in the germ-plasm of the species. Conclusive evidence of the presence or absence of such representation can be secured only by experimental breeding and especially by hybridizing the male offspring of workers of one species (a), with females of another (b) that has workers of a different character. Under these conditions some of the characters of a should make their appearance in b. The most favorable genera for such experiments would probably be *Myrmica, Formica,* and *Lasius,* in all of which there are species, subspecies, and varieties with distinctly characterized workers while the corresponding males and females are sufficiently alike to make hybridization seem feasible.

5. The Ethological and Psychological Aspects of Polymorphism.

In the foregoing discussion attention has been repeatedly called to adaptation as the insurmountable obstacle to our every endeavor to explain polymorphism in current physiological terms. Of course, this is by no means a peculiarity of polymorphism, for the same difficulty confronts us in every

biological inquiry. Adaptation, conceived as a phylogenetic process, and its ontogenetic counterpart, accommodation or regulation, are not only the central problems of all biology, but they constitute the proper field of ethology.[1] Emery,[2] and Waxweiler regard ethology as at bottom merely external physiology. The former defines it as treating of "the *ensemble* of phenomena whose physiological analysis has not yet been accomplished and is not even possible at the present time." This implies that when the analysis has been accomplished, ethology will be merged into physiology. Such a view is in my opinion open to discussion, since ethology also embraces the behavior, *i. e.*, the instinctive and intelligent actions by means of which organisms adapt or accommodate themselves to their environment and must be to that extent psychological. Hence there is opportunity for considerable difference of opinion in regard to the ultimate fate of ethology. Authors who believe that psychology will resolve itself into physiology will agree with Emery, whereas those who believe that biology will become increasingly psychological and metaphysical — and the number of these seems to be increasing — will predict that ethology will ally itself more closely with the mental sciences.

This dual possibility depends, of course, on two ways of envisaging the problem of adaptation. Those who view it from the physical (*i. e.*, mechanical), antiteleological and Neodarwinian standpoint, repudiate any attempt to substitute psychological terms in biological explanation, and assign as their reason for this course the existence of a psycho-physical parallelism. On the other hand, those who view the problem from the vitalistic, teleological and Lamarckian standpoint, turn to psychical manifestations like the will, with which we as acting subjects are perfectly familiar, as yielding a more adequate and satisfying insight into the phenomena. These different standpoints have been recently presented in violent contrast to each other in two works on adaptation by Detto[3] and Pauly.[4]

At first sight it may be difficult to understand why allusion should be made to these abstruse and very general matters in the discussion of a special subject like polymorphism. Reflection shows, however, that the social insects make a consideration of these matters necessary, since these organ-

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[1] An excellent discussion of the scope and problems of this science has been recently published by Waxweiler (Esquisse d'une Sociologie, *loc. cit.*, p. 29 *et seq.*). He has shown that Is. Geoffroy Saint Hilaire, in 1854, first introduced the term 'ethology' for the subject which Hæckel in 1866 designated as 'œcology' in his 'Generelle Morphologie.' The term 'bionomics' employed by Lankester, Baldwin, Gulick and others, is of course, of still more recent date. 'Ethology' therefore, not only has priority, but it is also more apt than the other terms that have been suggested. It will probably come into general use among English and American zoölogists, now that it has been adopted in such works as the 'Zoölogical Record.'

[2] Ethologie, Phylogénie et Classification. Comptes Rendus du 6 Congrès internat. Zool., Berne, 1904.

[3] Die Theorie der directen Anpassung und ihre Bedeutung für das Anpassungs-und Descendenzproblem. Jena, Gustav Fischer, 1904.

[4] Darwinismus und Lamarckismus, *loc. cit.*

isms are far and away the most plastic and adaptable and psychically the most richly endowed of all the lower animals. I use this term "psychically" advisedly, for, like Forel and Wasmann, I find myself utterly unable to accept the views of Bethe, Uexküll, and others, who regard the social insects as mere reflex machines. Nor have I the slightest hesitation in substituting psychological terms wherever physical terms are inadequate, as I am by no means convinced of the cogency of the hypothesis of psychophysical parallelism and the epistemological restrictions to which it is supposed to bind the investigator. If I am not greatly mistaken, psychophysical parallelism has of late received some pretty rough treatment at the hands of more than one eminent psychologist.[1]

As the type of polymorphism with which I have been dealing has been developed by psychically highly endowed social insects, it cannot be adequately understood as a mere morphological and physiological manifestation apart from the study of instinct. This has been more or less distinctly perceived by nearly all writers on the subject. However various their explanations, Spencer, Weismann, Emery, Forel, Marchal, and Plate all resort to instinct. Emery, especially, has seen very clearly that a worker type with its peculiar and aberrant characteristics could not have been developed except by means of a worker-producing instinct. In other words, this type is the result of a living environment consisting of the fostering queen and workers which instinctively control the development of the young in so far as this depends on external factors. Only under such conditions could a worker caste arise and repeat itself generation after generation. This caste may be regarded as a mutation, comparable with some of De Vries's *Œnothera* mutations, but able to repeat and maintain itself for an indefinite series of generations in perfect symbiosis with its parent form, the queen, because notwithstanding its relative infertility, it can be put to very important social use. Among ants this social use not only pervades the activities of the adult worker but extends even to the more inert larval stages. Thus the latter represent a rich and ever-fresh supply of food that can be devoured whenever a temporary famine overtakes the colony. In certain species, like the East Indian *Œcophylla smaragdina* and the South American *Camponotus senex*, the larvæ are put to a more humane use as spinning machines for constructing the silken nest inhabited by the colony. These examples also illustrate the purposive manner in which an organism can satisfy definite needs by taking advantage of ever-present opportunities.

In the lives of the social insects the threptic, or philoprogenitive instincts are of such transcendent importance that all the other instincts of the species,

[1] See, *e. g.*, Busse, Geist und Körper. Leipzig, Dürr'sche Buchhandlung, 1903; and Binet, L'Âme et le Corps. Paris, Ernest Flammarion, 1905.

including, of course, those of alimentation and nest-building, become merely tributary or ancillary. In ants, especially, the instincts relating to the nurture of the young bear the aspect of a dominating obsession. The very strength and scope of such instincts, however, renders these insects more susceptible to the inroads of a host of guests, commensals and parasites. besides the parasitic larvæ of Chalcidids, Lomechusini and *Metopina* described in the first part of this article, there are many adult beetles and other insects on which the ants lavish as much or even more attention than they do on their own brood. And when the ants themselves become parasitic on other ants, it is always either for the sake of having their own brood nurtured, as in the temporarily and permanently parasitic forms, or for the purpose of securing the brood of another species, as in the slave-making, or dulotic species.

The philoprogenitive instincts arose and were highly developed among the solitary ancestral insects long before social life made its appearance. In fact, social life is itself merely an extension of these instincts to the adult offspring, and there can be no doubt that once developed it reacted rapidly and powerfully in perfecting these same instincts. It is not so much the fact that all the activities of the social insects converge towards and center in the reproduction of the species, for this is the case with all organisms, as the elaborate living environment developed for the nurture of the young, that gives these insects their unique position among the lower animals. A full analysis of the threptic activities would involve a study of the entire ethology of the social insects and cannot be undertaken at the present time. Nevertheless the bearing of these instincts on the subject of polymorphism can hardly be overestimated and deserves to be emphasized in this connection.

All writers agree in ascribing polymorphism to a physiological division of labor among orginally similar organisms. This is tantamount to the assumption that the phylogenetic differentiation of the castes arose in the sphere of function before it manifested itself in structural peculiarities. Although this view implies that the female, or queen, was the source from which both the instincts and structures of the worker were derived, it has been obscured by an improper emphasis on the instincts of the honey-bee, in which the female is clearly a degenerate organism, and on certain specialized instincts, supposed to belong exclusively to worker ants like the slave-makers (*Polyergus* and *Formica sanguinea*). We have therefore to consider, first, the instincts of the queen and, second, any evidence that may go to show that instinct-changes precede morphological differentiation in the phylogeny of the species.

It is evident that the social insects may be divided into two groups according to the instinct rôle of the queens. In one group, embracing the

social wasps, bumble-bees, ants and termites, the female is the complete prototype of her sex. Even in the slave-making ants, as I have shown in a former article,[1] she manifests in the founding of her colonies all the threptic instincts once supposed to be the exclusive prerogative of the worker caste. These may be called the primary instincts. After the colony is established, however, and she no longer needs to manifest these instincts, she becomes a mere egg-laying machine and her instincts undergo a corresponding change. These may now be designated as secondary instincts. She thus passes through a gamut of instincts successively called into activity by a series of stimuli which in turn arise in a definite order from her changing social environment. The workers, however, are capable of repeating only a portion of the female gamut, the primary series. In gynæcoid individuals there is also a tendency to take up the secondary series, but in most workers this has been suppressed by countless generations of nutricial castration. The social insects of this type may be called *gynæcotelic*, to indicate that the female has preserved intact the full series of sexual attributes inherited from her solitary ancestors. In these the primary and secondary series were simultaneous or overlapped completely, in the gynæcotelic social insects they are extended over a longer period of time and overlap only in part, as social life permits the extension of the secondary long after the primary series has lapsed into desuetude. It will be seen that the division of labor which led to the spacial differentiation of like females into workers and queens is clearly foreshadowed in the consecutive differentiation of instincts in the individual queen.

The second group of social insects is represented by the honey-bees and probably also by the stingless bees (Meliponidæ). In these insects only the secondary instincts are manifested in the queen, while the worker retains the primary series in full vigor and thus more clearly represents the ancestral female of the species. This type may therefore be called *ergatotelic*.[2]

The suppression of the primary instincts in the queen honey-bee was undoubtedly brought about by a change in the method of colony formation. When the habit of swarming superseded the establishment of colonies by solitary queens, as still practiced by the gynæcotelic insects, the primary instincts of the female lapsed into abeyance or became latent. This change took place so long ago that it has had time to express itself in the structure of the queen honey-bee as compared with the worker (shorter tongue and wings, feebler sting, degenerate structure of hind legs, etc.).

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[1] On the Founding of Colonies by Queen Ants, etc., *loc. cit.*

[2] The distinction of gynæcotelic and ergatotelic types corresponds with Cook's "principles of matriarchy and ergatarchy" (The Social Organization and Breeding Habits of the Cotton-protecting Kelep of Guatemala. U. S. Depart. Agric., Bull. Entom., Tech. Series No. 10, 1905, p. 34). These terms are objectionable because they imply an erroneous, not to say anthropomorphic, conception of governing or ruling on the part of the queen or workers.

The first of the following examples, which seem to indicate the occurrence of instinctive prior to morphological differentiation, shows at the same time how the ergatotelic type of the honey-bee arose from the gynæcotelic type of the social wasps and bumble-bees.

1. The queens of certain species of *Formica* (*F. rufa, exsectoides,* etc.) are no longer able to establish colonies without the coöperation of workers. The common method of colony formation among these insects is by a process of swarming like that of the honey-bee: a certain portion of the colony emigrates and founds a new nest with one or more of the queens. When this method is impracticable the young queen seeks the assistance of an allied species of *Formica* (*F. fusca*), the workers of which are willing to perform the same function as those of her own species in rearing her brood. In *F. rufa* and *exsectoides* there is nothing in the stature or structure of the queen to indicate the presence of these parasitic instincts, but, in many of the allied species like *F. ciliata, montigena, microgyna,* etc., the colonies of which are smaller and no longer swarm, or do so only to a very limited extent, the queens have become more dependent on the workers of other species of *Formica* and have developed mimetic characters or a dwarf stature to enable them to enter and exploit the colonies of alien species.

2. In many ants the callows, or just-hatched workers, confine themselves to caring for the larvæ and pupæ and do not exhibit the foraging instincts till a later period. But even the adult workers may perform a single duty in the colony for long periods of time, if not indefinitely. Thus Lubbock,[1] and Viehmeyer,[2] have observed in certain nests of *Formica* that only certain individuals forage for the community. The latter has also noticed that certain other individuals, indistinguishable morphologically from their sister workers, stand guard at the nest entrances. In other genera, like *Camponotus, Atta, Pheidole,* etc., with species that have desmergates, the morphological differentiation between foragers and guardians is still unsettled. It becomes completely established, however, in certain genera and species with the suppression of the desmergates. A remarkable example of division of labor without corresponding structural differentiation is seen also in the above-mentioned *Œcophylla,* an ant which inhabits nests of leaves sewn together with fine silk. According to the observations of Dodd[3] and Doflein,[4] when the nests are torn apart the monomorphic workers separate into two companies, one of which stations itself on the outside of the nest, draws the separated leaves together and

[1] Ants, Bees, and Wasps. Revised ed., New York, Appleton & Co., 1894, pp. 45–47.
[2] Experimentelle Untersuchungen, etc., *loc. cit.*, p. 336.
[3] Notes on the Queensland Green Tree Ant (*Œcophylla smaragdina* Fab.?). Victor. Natural., XVIII, 1902, pp. 136–140.
[4] Beobachtungen an den Weberameisen (*Œcophylla smaragdina*), Biol. Centralbl., XXV, 1905, pp. 497–507, 5 figs.

holds them in place with the claws and mandibles, while the other moves the spinning larvæ back and forth within the nest till the rent is repaired with silken tissue.

3. An interesting case is presented by the honey-ants (*Myrmecocystus melliger* and *mexicanus*). All the workers of these species, though variable in size, are structurally alike. Among the callows, however, and quite independently of their stature, certain individuals take to storing liquid food, as I have found in my artificial nests of the latter species, and gradually in the course of a month or six weeks become repletes, or plerergates. Except for this physiological peculiarity, which gradually takes on a morphological expression, the plerergates and ordinary workers are indistinguishable. We must assume, therefore, that the desire to store food represents an instinct specialization peculiar to a portion of the callow workers. There can be no doubt that as our knowledge of the habits of ants progresses many other cases like the foregoing will be brought to light.

It may be maintained that in these cases physiological states must precede the manifestation of the instincts, and that these states, however inscrutable they may be, are to be conceived as structural differentiations. There is undoubtedly much to justify this point of view. The elaborate sequence of instincts in the queen ant, for example, is accompanied by a series of physiological changes so profound as to be macroscopical. After the loss of her wings, the wing muscles degenerate and the fat-body melts away to furnish nourishment for the ovaries, which in the old queen become enormously distended with eggs as the breeding season approaches. Such changes would seem to be amply sufficient to account for the changing instincts. As I have shown,[1] mere artificial deälation at once alters the instincts of the queen, probably through a stimulus analogous to that which leads to the atrophy of a muscle when its nerve is severed, and in the case under consideration leads to the degeneration of the wing-muscles and to changes in the ovaries.

In the mermithergates and pseudogynes described in the first part of this paper, the aberrant instincts may be referred to peculiar physiological states. Similarly nutricial castration itself, considered as an instinct, may be said to be the result of the physiological state of hunger. There is indeed every reason to suppose that the worker, both in its ontogenetic and phylogenetic development, is through and through a hunger-form, inured to protracted fasting. Miss Fielde has shown,[2] that the workers of *Camponotus americanus* may live nearly nine months without food, which is as long

[1] On the Founding of Colonies, etc., *loc. cit.*, p. 103.
[2] Tenacity of Life in Ants. Biol. Bull., VII, No. 6, Nov. 1904, p. 300; and *ibid.*, Temperature in the Development of Ants, *loc. cit.*, p. 366.

as the much larger and more vigorous queens are known to fast while establishing their colonies. The larvæ of ants, too, are known to remain alive in the nests for months without growing. And even when food is abundant the workers appropriate very little of it to their individual maintenance but distribute it freely among their sister workers, the brood and queen. It is not improbable, moreover, that the single instinct peculiar to workers, the instinct to leave the nest and forage, is the direct result of a chronic state of hunger.

Undoubtedly such physiological states are neither more nor less mysterious than those of man and the higher animals, in which they are universally recognized as leading to changes in the instinctive and emotional life of the individual. We may not only concede the existence of physiological states in the above and many other cases, but we may also admit that this concession is favorable to the hypothesis of psychophysical parallelism. On looking deeper into the matter, however, we find that our knowledge of the physiological states, and especially of their precise connection with the instincts, is extremely vague and unsatisfactory. Furthermore, we are compelled to confess that even the simplest physiological reaction, the simplest reflex depending on the simplest of physiological states, such as the general irritability of all living matter, still involves a non-mechanical or teleological and therefore a psychological factor, to the understanding of which the hypothesis of psychophysical parallelism contributes nothing. The interpretation of organic behavior as the result of "trial and error" seems to have a value in indicating that the teleological factor is a blind activity groping for the means with which to supply an organic need. But not only is this conception borrowed from psychology but it is thoroughly teleological, since the eventual selection and retention on the part of the organism of the particular mode of reaction best suited to supply its needs, is incapable of a mechanical explanation. Of course, 'teleology' as applied to biological phenomena must not be understood in the sense of an altruistic or external teleology like the 'design' of theologians but is, as Pauly has shown,[1] an immanent and egotistical principle capable of great simplification in the lower biological units like the cells, without losing its essentially purposive character.

Driesch,[2] in his attempt to establish the autonomy of the vital processes on the basis of regulatory phenomena in ontogeny, says: "A special problem which is calculated to lead to a parallelism between the instincts and ontogeny, may be briefly mentioned in conlcusion: the course of ontogeny may

[1] Darwinismus and Lamarckismus, *loc. cit.*, pp. 15–22.
[2] Die "Seele" als Elementarer Naturfaktor, Leipzig, Wilhelm Engelmann, 1903, p. 26.

be interfered with, but it regulates itself; and from the study of just such regulations important insight has accrued to morphology. Will it also be possible to bring about regulations in instinctive processes? No definite answer can be given to this question at the present time." He goes on to say that if they should prove to be capable of such regulations, the instinctive reactions would present further evidence of the autonomy of living organisms.

It seems to me that there are, especially in the social insects, a few facts which point to such regulations in the sphere of instinct. When, for example, the firstling brood is removed from a queen ant that has just manifested her primary series of instincts, she will proceed to rear another brood, although under normal circumstances she would pass on to the purely secondary series of reactions. In this case the absence of a colony acts as a stimulus to produce a highly adaptive regulation, which is equivalent to a regeneration of the colony. If on the other hand the queen ant, wasp, or termite is removed from her colony, some of the remaining workers themselves become gynæcoid and function as substitutional queens, or in bees raise a new queen. A similar regulation of the personnel of the colony is also apparent in other cases, as when strange queens are adopted or the numerical proportions of the different castes are regulated. If we accept Wasmann's view of the production of pseudogynes in *Formica* nests infested with Lomechusini, the conversion of queen larvæ into workers would be a splendid example of regulation. Such facts point to instinct as offering evidence as important as that of ontogeny in support of a vitalistic conception. And even if my interpretation of the pseudogynes as the result of simple neglect and starvation be accepted, we still have an interesting case of regulation, for the pseudogynes of *Formica*, like the phthisergates of *Pheidole instabilis* and the mermithergates of *Ph. commutata*, are the result of a tendency to produce a symmetrical and adaptive whole out of formative materials that have been abnormally depleted, augmented, or disturbed in the course of their development through the action of parasites.

In concluding this rather long discussion of polymorphism it is hardly necessary to point out that I have added little of constructive value apart from a few suggestions and a clearer definition of some of the problems involved in an extremely intricate subject. If I have succeeded in showing that the underlying problem is the same as that of all other biological phenomena, and that the social insects cannot be used to support any of the current mechanical conceptions of development, my object will have been achieved.

EXPLANATION OF PLATES.

Plate I.

Fig. 1. — *Pheidole kingi* André var. *instabilis* Emery. Soldier, Austin, Texas.
Figs. 2–6. — Series of intermediate forms (desmergates) between the soldier and worker of *Ph. instabilis*.
Fig. 7. — Typical worker of same.
Fig. 8. — Deälated female of *Ph. instabilis*.
Fig. 9. — Male of same.
Fig. 10. — *Orasema viridis* Ashmead. Female. Austin, Texas.
Fig. 11. — *Orasema viridis*. Male.
Fig. 12. — *Orasema coloradensis* Ashmead. Female. Colorado Springs, Colorado.

Plate II.

Fig. 13. — Phthisergate of *Ph. instabilis* with very young *Orasema viridis* larva attached to the right side of the prothorax beneath the fore leg.
Fig. 14. — Soldier semipupa of *Ph. instabilis* with *O. viridis* larva in second stage attached to the presternal region between the first and second pairs of legs.
Fig. 15. — Female semipupa of *Ph. instabilis* with *O. viridis* larva in the second stage attached to the pronotal region behind the head.
Fig. 16. — Female semipupa of *Ph. instabilis* with *O. viridis* larva in the third stage attached to the presternal region.
Fig. 17. — Female semipupa of *Ph. instabilis* with nearly mature *O. viridis* larva (shrunken by reagents) attached to the sternal surface between the middle and hind pairs of legs. From a specimen mounted in balsam.
Fig. 18. — Female pupa (phthisogyne) of *Ph. instabilis* with *O. viridis* semipupa in the pustulate stage, still attached in the position which it occupied as a larva. From a specimen mounted in balsam.
Fig. 19. — Female pupa (phthisogyne) with *O. viridis* semipupa in the pustulate stage, still attached to the sternal region. From an alcoholic specimen.
Fig. 20. — Semipupa of *O. viridis*, viewed as a transparent object, showing the head, wings, and legs developing beneath the hood-like prothoracic mass. From a specimen mounted in balsam.
Fig. 21. — Semipupa of *O. viridis* in a more advanced stage. From a specimen mounted in balsam.
Fig. 22. — Pupa of female *O. viridis* just before pigmentation, showing the prominent intersegmental abdominal welts.
Fig. 23. — Pigmented pupa of *O. viridis* nearly ready to hatch.
Fig. 24. — Phthisergate of *Ph. instabilis* viewed in profile as an opaque object. From an alcoholic specimen.
Fig. 25. — Phthisergate of *Ph. instabilis* in ventral view to show the greatly attenuated thorax, small projecting eyes, etc.

Fig. 26. — Phthisergate of *Ph. instabilis* viewed as a transparent object to show the urate masses in the gaster. From a specimen mounted in balsam.

Fig. 27. — Normal worker pupa of *Ph. instabilis* in profile. From an alcoholic specimen.

Fig. 28. — Phthisergate of *Ph. dentata* Mayr. From an alcoholic specimen.

Fig. 29. — Worker cocoon of *Camponotus herculeanus ligniperdus* var. *novæboracensis* Fitch, from northern Michigan, showing an enclosed pair of pupæ of *Pseudochalcura gibbosa* Provancher near the anterior pole, and the remains of the consumed *Camponotus* semipupa applied to the black meconial spot at the posterior pole.

Figs. 30–35.— Six larvæ of *Orasema viridis* in the youngest stage observed, corresponding with the one shown in Fig. 13.

Plate III.

Fig. 36. — *Pheidoloxenus wheeleri* Ashmead. Female, taken from a colony of *Ph. instabilis* at Austin, Texas.

Fig. 37. — *Pheidole dentata* var. *commutata* Mayr. Soldier. New Braunfels, Texas.

Fig. 38. — *Ph. commutata.* Worker.

Fig. 39. — Mermithergate of *Ph. commutata,* drawn to the same scale as Figs. 37 and 38; showing *Mermis* parasites in the distended gaster. The head of the ant bears occelli; the thorax is shaped like that of the soldier.

Fig. 40. — Lateral view of same mermithergate.

Fig. 41.— *Xenodusa cava* Leconte, taken from a colony of *Formica schaufussi* var. *incerta* Emery at Colebrook, Connecticut.

Fig. 42. — *Formica schaufussi* Mayr. var. *incerta* Emery. Normal worker. Colebrook Connecticut.

Fig. 43. — Pseudogyne of *F. incerta* drawn to the same scale as Fig. 42.

Fig. 44. — Pseudogyne from the same colony as Fig. 43, showing a somewhat different conformation of the thorax.

Plate IV.

Fig. 45. — Pseudogyne of *Myrmica rubra brevinodis* Emery var. *sulcinodoides* Emery, with vestige of left fore wing, from Isle Royale, Michigan.

Fig. 46. — Thorax of same in profile.

Fig. 47. — Thorax of normal worker of *M. sulcinodoides.*

Fig. 48. — Thorax of pseudogynic *M. rubra scabrinodis* Nyl. var. *schencki* Emery, from Jeanette, Pennsylvania. This specimen has minute vestiges of both fore wings.

Fig. 49. — Lateral view of same.

Fig. 50. — Pseudogyne of *Formica rufa obscuriventris* Mayr. var. *melanotica* Emery, with well-developed mesonotum, scutellum and metanotum, from Rockford, Illinois.

Fig. 51. — Dorsal view of thorax of same.

Fig. 52. — Pseudogyne of *F. melanotica* with more convex mesonotum, from the same colony as the specimen shown in Figs. 50 and 51.

Fig. 53. — Pupa of female *Orasema coloradensis* Ashm.; dorsal view showing the arrangement of the pustules.

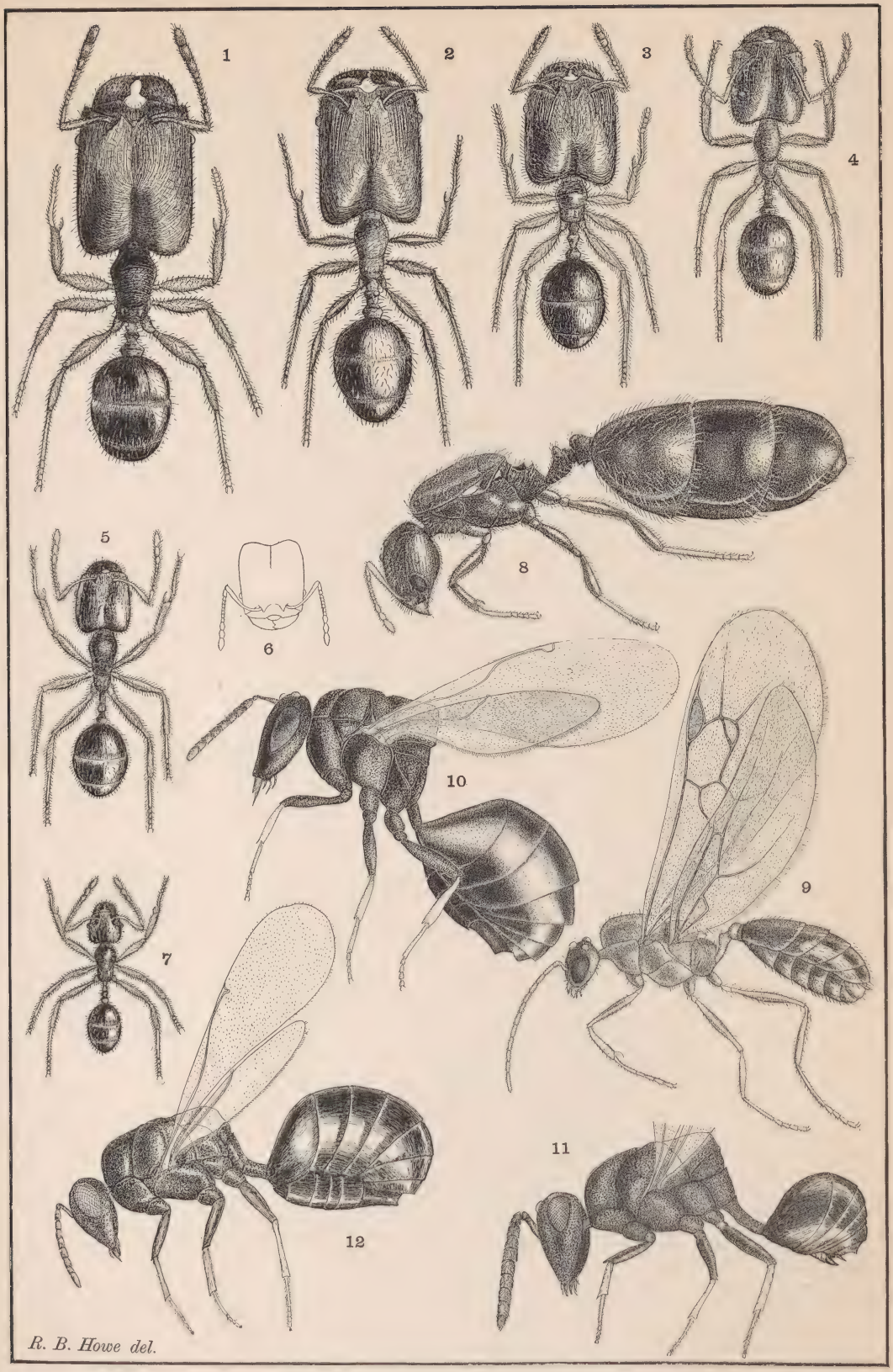
Fig. 54. — Lateral view of same.
Fig. 55. — Pupa of female *Pseudochalcura gibbosa* Prov., from northern Michigan.
Fig. 56. — *Kapala floridana* Ashmead. Female, from eastern Florida. From a specimen in the United States National Museum.
Fig. 57. — *Kapala floridana*. Male, from eastern Florida. From a specimen in the United States National Museum.
Fig. 58. — *Isomeralia coronata* Westwood. Female, from Pernambuco, Brazil. From a specimen in the United States National Museum.
Fig. 59. — Lateral view of same.
Fig. 60. — *Dicælothorax platycerus* Ashmead. Female. After Ashmead.
Fig. 61. — Scutellum of same, seen from above. After Ashmead.
Fig. 62. — *Eucharis* sp. Male, from the top of the Las Vegas Range, New Mexico (11,000 ft.).

Plate V.

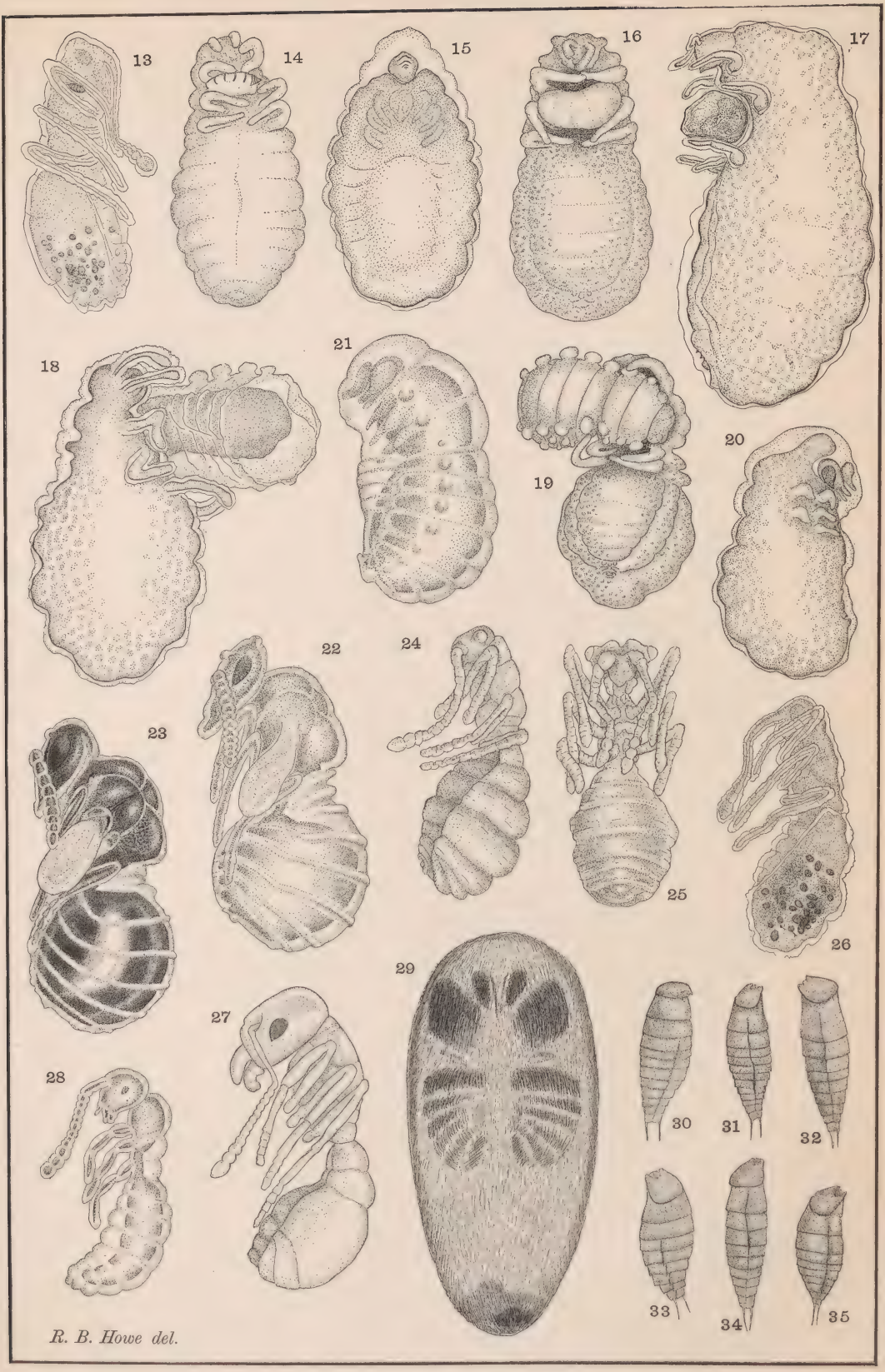
Fig. 63. — *Pheidole instabilis*; *a*, females (winged and deälated); *e*, male; *o*, soldier; *c*, workers; *r*, intermediates (desmergates); *m*, *Orasema viridis*, female; *n*, male. × 2.
Fig. 64. — Brood of *Ph. instabilis*; *a*, female larvæ and pupæ; *e*, male pupæ and semipupæ; *o*, soldier pupæ; *c*, worker larvæ and pupæ; *r*, pupæ of desmergates; *m*, *O. viridis*, adult female, *m′*, pupæ and semipupæ; *n*, male; *n′*, pupæ of same. × 3.
Fig. 65. — Brood of *Ph. instabilis*. Letters as in the preceding figure; *s*, phthisergates. × 3.
Fig. 66. — Three female semipupæ (phthisogynes) of *Ph. instabilis* bearing larvæ of *O. viridis* on their sternal surfaces. × 3.
Fig. 67. — Worker brood of *Ph. instabilis*; *c*, normal worker pupæ and semipupæ; *i*, phthisergates; *r*, intermediate (desmergatic) phthisergate. From specimens mounted in balsam.
Fig. 68. — *Solenopsis molesta validiuscula* Emery; *a*, female; *e*, male; *c*, workers; *m*, *Orasema coloradensis*, female.
Fig. 69. — Brood of *Pachycondyla harpax* Fabricius. The larvæ marked *x* each bear a larva of *Metopina pachycondylæ* Brues; *z*, detached *Metopina* larva; *v*, puparium of *Metopina*; *u*, cocoon of *Pachycondyla*.

Plate VI.

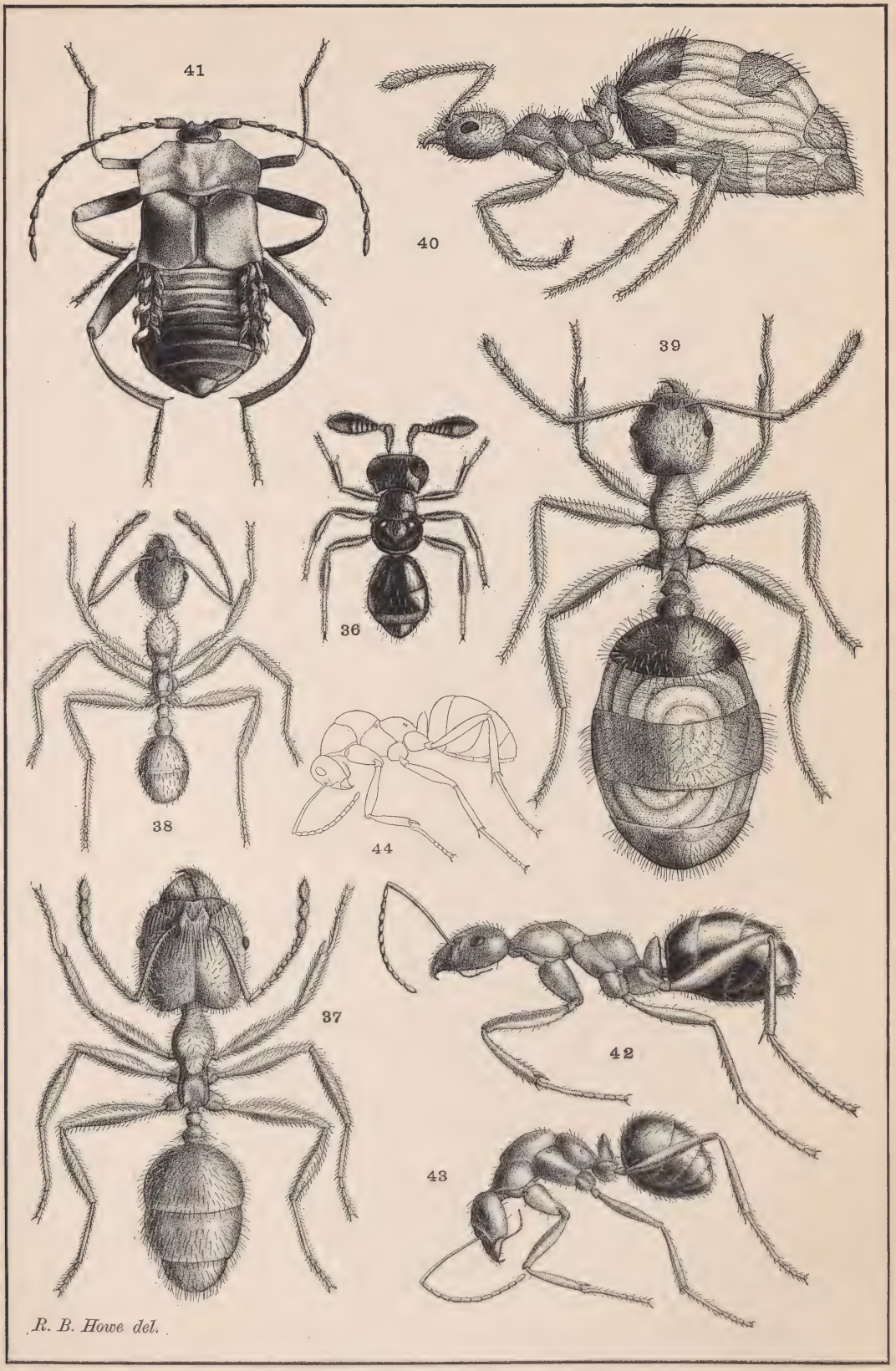
Diagram to illustrate the relationships of the typical and atypical phases of ants. The three typical phases are placed at the angles of an isosceles triangle, the excess developments to the right, the defect developments to the left of a vertical line passing through the middle of the diagram. The normal atypical phases are in ordinary, the pathological phases in italic type. The arrows indicate the direction of the affinities of the atypical phases. The phases arranged on the sides of the triangle are annectant, those radiating outward from its angles are new departures showing excess or defect characters. For definitions of the different phases see pp. 53 to 57.



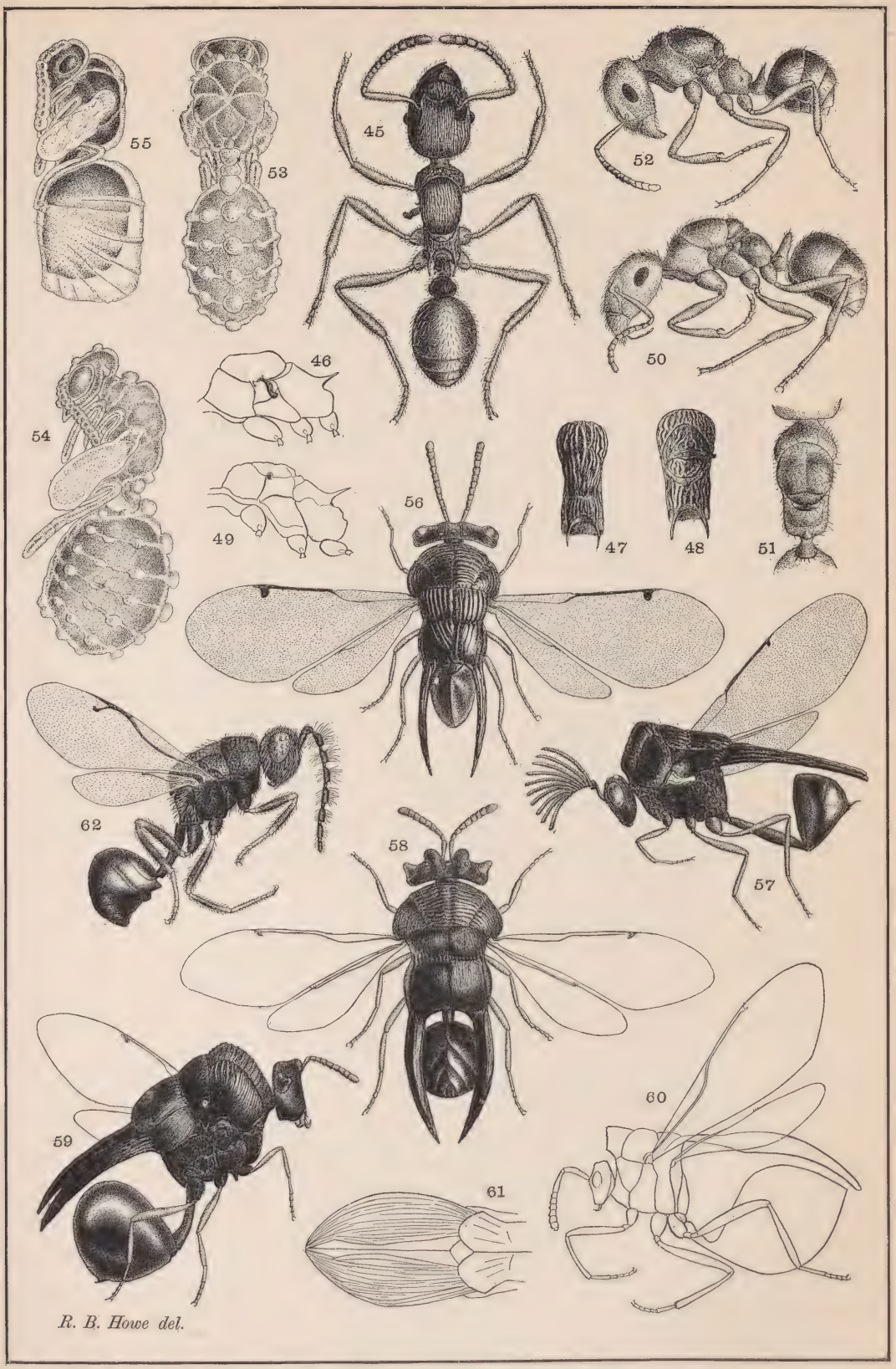
Pheidole instabilis and Orasema.



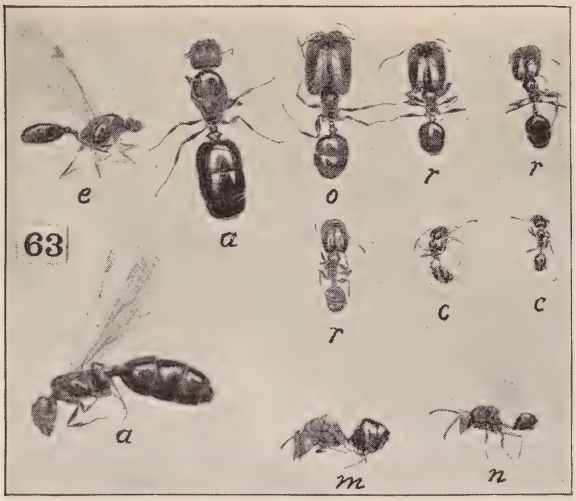
Development of Orasema

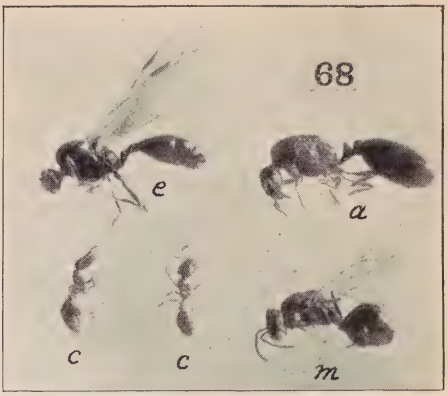


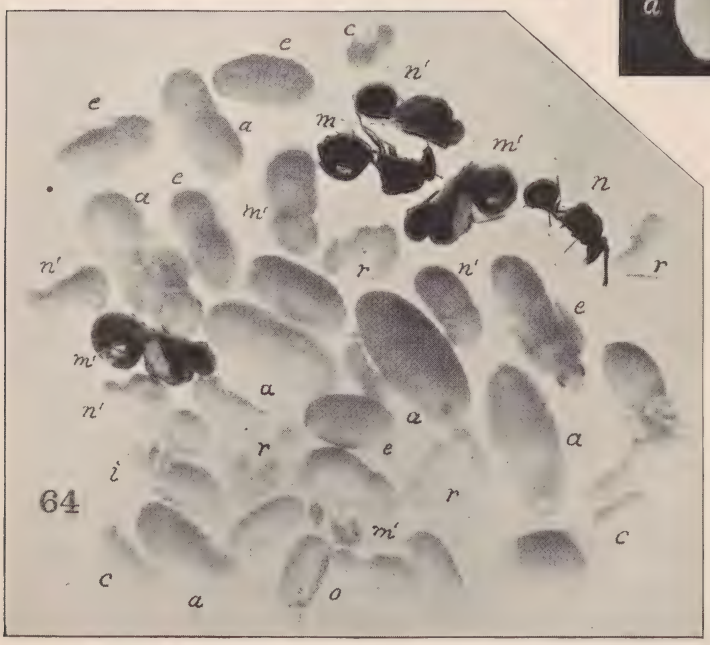
Parasites of Pheidole and Formica.

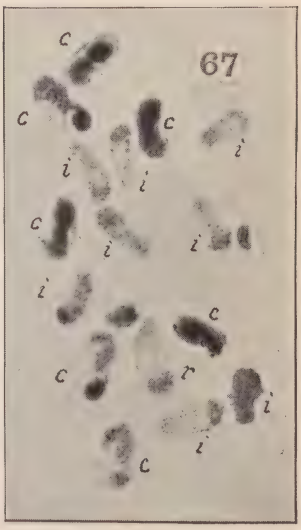


Chalcidid Parasites of Ants, etc.

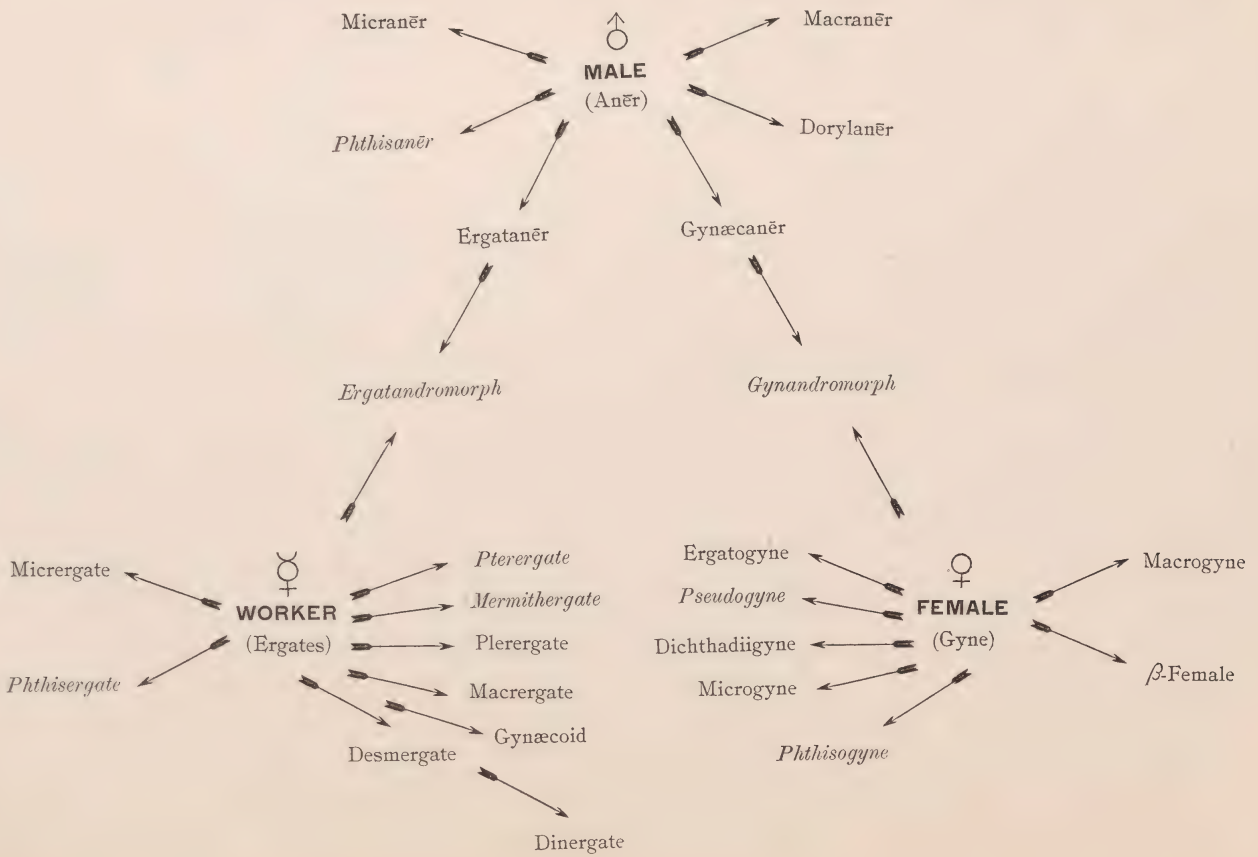








Parasites of Pheidole, Solenopsis and Pachycondyla.



The Typical, Atypical and Pathological Phases of Ants.

59.7(728)

Article II. — THE FISHES OF THE MOTAGUA RIVER, GUATEMALA.[1]

By Newton Miller.

During January, February, and March of 1905, I collected fishes in the Rio Motagua basin of Guatemala from an elevation of 60 to 900 feet. I was the only member of a party of botanists and zoölogists exclusively engaged in collecting fishes but received assistance from Mr. E. B. Williamson, Mr. C. C. Dean, and Prof. J. Hines, three members of our party. I am much indebted to the authorities of the Ferrocarril del Norte de Guatemala and the Ferrocarril Central de Guatemala for kindness and valuable assistance. I am no less indebted to Dr. C. H. Eigenmann under whose direction I made this collection and prepared this paper.

In a recent paper (Fresh-water Fishes of Mexico) Meek has shown that the North and South American faunas overlap in Mexico. The prime object of my work in Guatemala was to determine to what extent the fauna of the Motagua basin contains representatives of the North and South American faunas, respectively, and what is autochthonous.

The Motagua basin has a general east-west trend from the Gulf of Honduras to within about 50 miles of the Pacific coast. Collections were made in the following localities: Tenedores, Los Amates, Algeria, Gualan, Zacapa, and El Rancho. Other collections were made at Puerto Barrios and Santa Lucia not in the Motagua basin.

Character of Collecting Stations.

1. *Stream at Edge of Puerto Barrios.*— At the edge of Puerto Barrios a small stream empties directly into the Gulf of Honduras. The water of this stream is dark, sluggish, and contains much dirt. The banks are low, overgrown with low elbowed bushes which extend out over the water. I collected only in the mouth of this stream where the bottom is composed of sand and mud.

Altitude 0.

2. *Swamps West of Puerto Barrios.*— The region west of Puerto Barrios for about 50 miles contains many swamps. The water is very dark and full of decaying vegetable matter. About the edges of the swamps is a dense growth of bushes and trees and in some cases the marginal water is full of water plants. The swamps examined are 2 to 3 miles west of Puerto Barrios and when examined were about 4½ feet deep. Seining

[1] Contributions from the Zoölogical Laboratory of Indiana University, No. 73.

was almost impossible on account of logs and brush. Dynamite was used with very little success.

Altitude 60 to 80 feet.

3. *Sulphur River.*— Sulphur River is a short stream emptying into the Bay of Honduras. Collections were made 3½ and 5½ miles west of Puerto Barrios near the railroad. In the upper part of the stream, 5½ miles west of Puerto Barrios at an elevation of 80 feet, the water is very warm, 32.2° C., and strongly charged with sulphur. The stream here has numerous small falls, the bottom being rocky and gravelly.

Three and a half miles from Puerto Barrios, with an altitude of 40 feet, the water is much cooler and not so clear. The bottom here is sandy or solid rock with occasional large boulders.

4. *Rio Machaca,*[1] *four miles east of Tenedores.*— This stream, a tributary of the Motagua, is about 45 feet wide, deep, swift, and with steep banks. Its bottom for the most part is sandy. Very little brush and but few logs are lodged in it. Its course is through a growth of vegetation, so dense that we had to cut our way through it to the stream.

Altitude 64 feet; temperature 26° C.

5. *Rio Negro near Tenedores.*— Rio Negro is a small, sluggish, swamp stream tributary to the Motagua. The abundance of vegetable matter makes its water a dirty brown. It is deeply shaded for the most part by overhanging boughs and vines that trail over them.

I was not able to seine this stream at all on account of the brush in it, but I secured a few specimens with dynamite.

Altitude 68 feet.

6. *Rio Tenedores at Tenedores.*— Collections were made in this stream for a quarter of a mile from where it empties into the Motagua. Its water was clear enough to show the bottom at a depth of about two feet. The river is not swift at this point. Above it is much more rapid. The bottom is sandy and for the most part free from brush. Seining would be easy but for the steep banks. Trees and shrubs are here few. The average width of the stream is about 40 feet and its depth in places 7 or 8 feet. Cichlids were taken in abundance, especially *Cichlasoma spilurum.*

Altitude 85 feet; temperature 27° C.

7. *Rio Kilagua at Los Amates.*— The water of this tributary of the Motagua is ordinarily clear, but becomes very muddy for a short time after a rain. The bottom is sandy. The banks are steep, with dense vegetation up to their edges. Vines overrun the trees and hang down into the water in places. These vines often catch brush and form a drift in the stream about which some species of Cichlid are more abundant

[1] Machaca is the name given by the natives to the largest of the fresh-water fishes, *Brycon dentex,* and on account of its abundance in this stream, the stream has been called Machaca.

than elsewhere. Collections were made by setting a seine across the river below one of the drifts and then dynamiting the place. The water is swift enough to wash the dead and stunned fishes into the net. *Astyanax æneus* was the only species taken in abundance from this river.

Altitude 260 feet; temperature 26.5° C.

8. *Pond North of Los Amates.*— A large pond was discovered about half a mile northeast of Los Amates. Its water contains vegetable matter in abundance. All about the pond are palms and large trees. Weeds and water plants grow out into the pond to a depth of about four feet, leaving only about 60 feet of the central portion of the pond free from plants. Seining here was a difficult matter. We succeeded in getting a few specimens of *Xiphophorus helleri* and *Belonesox belizanus*.

Altitude 260 feet; temperature 27° C.

9. *Rio Managua at Algeria.*— This river is swift with now and then deep holes that can be seined. The bottom is either gravelly or sandy. Landing places are good. In some places there is so much drifting sand that it fills the seine; in other places are large boulders. Algeria is near the mountains and the stream is here practically a mountain torrent.

Altitude 280 feet; temperature 26.5° C.

10. *Rio Gualan at Gualan.*— This river, a tributary of the Motagua, is a mountain torrent, with few pools that are waist deep. Its water is clear and swift, so swift indeed that a forty-foot seine can scarcely be stretched across it. No mud bottom was found in the river proper. The bottom is covered with pebbles or small boulders, about the size of a man's fist. No brush was found in this stream at all. Fishes are few in this river both in species and individuals.

More species were taken from a small fork of the Rio Gualan whose water was clear and sluggish than from the river proper. This stream flows through a field, is about 15 feet wide and has deep pools and sandy bottom. *Heterandria lutzi* and *Pœcilia sphenops*, abundant.

Altitude 430 feet; temperature 26.5° C.

11. *Rio Motagua at Gualan.*— The Rio Motagua is a mountain stream from here to its source. Its water is not very clear. The bottom consists of sharp jagged rocks in places, or is sandy or sandy with large boulders. The water was so swift and deep that we were able to seine only in eddies. Vegetation about the river is not dense. This region is in an [illegible] condition during the dry season.

Altitude 430 feet; temperature 26° C.

12. *Rio Motagua at Zacapa.*— The Motagua here is rather clear, swift and deep. Its bottom is rocky in some places and sandy in others. The river is so swift and deep that we were able to take specimens only

from a branch of the river where it flows past an island. Surroundings similar to those at Gualan.

Altitude 600 feet; temperature 26.5° C.

13. *Rio Motagua at El Rancho.*— The river at this point is very swift and full of sand that is washed about continually. Its width averages about 60 feet. A satisfactory haul of the seine was impossible on account of the sand suspended in the water. Dynamite was used to little advantage. The region is almost a desert from January first to June first.

Altitude 900 feet; temperature 25.5° C.

14. *Spring at Santa Lucia.*— This town is on the western slope along the Southern railroad. A few specimens were taken from a small spring that had almost dried up.

Altitude 1045 feet.

The Sources of the Motagua River Fish Fauna.

The chief object in making this collection was to determine to what extent the fauna of the Motagua River is related to that of North and South America. Meek has shown that the North American fauna has forced its way southward at least as far as the Isthmus of Tehuantepec. Thus the river Papaloapam, emptying into the Gulf of Mexico from the Isthmus of Tehuantepec, harbors 37 species, four of which represent North American types. Of the 27 species taken from the Motagua system none represent the North American fauna; South America is represented by three genera of Characins each with a very wide distribution in Central and South America, a Gymnonotid universally distributed in the lower levels of tropical America from the Motagua to the La Plata; *Symbranchus marmoratus* which has even a wider distribution; a catfish, *Rhamdia godmani,* of a genus with a universal distribution in tropical America; eleven Cichlids whose centre of distribution is the Orinoco River. The Cichlids have undergone numerous local adaptations in Central America where the genera *Cichlasoma, Thorichthys,* and *Heros* have their principal location.

The remaining species are either derivitives from the sea direct or belong to the Middle American types of Gobiidæ and Pœcilidæ. I have given the distribution of each genus occurring in the Motagua basin to show the relation of the Motagua region to the general fauna.

I have included in this paper 5 species not taken from the Motagua system. These are: *Cichlasoma globosum* and *Gambusia nicaraguensis* from the brackish water about Puerto Barrios; *Cichlasoma nebuliferum* and *Heros salvini* from Sulphur River near Puerto Barrios; *Heterandria pleurospilus* from a spring at Santa Lucia on the western slope.

Table showing Localities at which the species were taken.

	Brackish water, Pto. Barrios.	Swamps 2 to 3 mi. west of Pto. Barrios.	Sulphur River 3½ mi. from Pto. Barrios.	Sulphur River 5½ mi. west Pto. Barrios.	Machaca River, Tenedores.	Rio Negro, Tenedores.	Rio Tenedores, Tenedores.	Rio Kilagua, Los Amates.	Ponds & swamps, Los Amates.	Brooks, Los Amates.	Rio Manugua, Algeria.	Rio Gualan, Gualan.	Rio Motagua, Gualan.	Rio Motagua, Zacapa.	Rio Motagua, El Rancho.	Spring, Santa Lucia.
1. Rhamdia godmani		×					×	×	×	×	×					
2. Hemigrammus compressus									×							
3. Astyanax æneus			×	×	×	×	×	×	×	×	×	×	×	×	×	
4. Brycon dentex			×		×		×	×		×	×	×	×	×	×	
5. Gymnotus carapo		×							×	×						
6. Rivulus elegans										×						
7. Pseudoxiphophorus bimaculatus		×							×	×		×				
8. Gambusia nicaraguensis	×															
9. Belonesox belizanus		×				×	×		×		×					
10. Heterandria pleurospilus																×
11. Heterandria lutzi											×	×	×			
12. Pœcilia sphenops	×	×					×		×		×	×	×	×	×	×
13. Pœcilia amates										×						
14. Xiphophorus helleri		×	×					×	×	×	×	×				
15. Agonostomus monticola							×	×						×	×	
16. Thyrina meeki							×	×			×	×	×	×	×	
17. Philypnus dormitor			×				×									
18. Awaous taiasica			×					×			×	×	×			
19. Cichlasoma spilurum		×	×				×	×			×	×	×			
20. Cichlasoma hedricki		×				×		×		×						
21. Cichlasoma globosum	×															
22. Cichlasoma mañana							×	×			×					
23. Cichlasoma acutum							×	×				×				
24. Cichlasoma nebuliferum			×	×												
25. Heros friederichsthalii							×	×	×		×	×	×			
26. Heros salvini			×	×												
27. Heros microphthalmus							×	×			×		×	×	×	
28. Thorichthys helleri			×			×										
29. Thorichthys ellioti							×	×			×	×	×	×		
30. Centropomus mexicanus					×											
31. Pomadasys templei			×		×											
32. Symbranchus marmoratus									×							

FISHES RECORDED FROM THE MOTAGUA BASIN NOT IN MY COLLECTION.

a. Heros oblongus (non Casteln.); Günther, Trans. Zoöl. Soc., VI, 1869, p. 464; Jordan & Evermann, Fishes of North and Middle America, 1535, 1898.

Cichlasoma güntheri Pellegrin, Mem. Soc. Zool. France, XVI, 1903, 215 (1894); Regan, Ann. and Mag. Nat. Hist. (7), XVI, 233, Aug. 1905, (Rio Motagua).

b. Rhamdia motaguensis Günther.

As nothing is known of the variability of the tropical fishes I have in most cases made extensive tables of measurements which are summarized under the respective species.

SILURIDÆ.

This family is represented by about 25 species in the fresh waters of North America and by over 200 species in tropical America. Those of North America belong to a different subfamily from those of South America.

Rhamdia *Bleeker.*

Geographical distribution: streams south of Vera Cruz, Rio Motagua system, rivers of Panama, and southward to western Peru and the Rio de la Plata.

1. **Rhamdia godmani** (*Günther*).

Pimelodus cinerascens KNER & STEINDACHNER, Abh. Bay. Ak., X, 49 (not of Günther).

Pimelodus godmani GÜNTHER, Cat. Fish. Brit. Mus., V, 1864, 124 (Lower Vera Paz; Rio Motagua; Mexico).

Rhamdia godmani JORDAN & EVERMANN, Fishes of North and Middle America, I, 152, 1896.

Pimelodus wagneri GÜNTHER, Fishes Cent. America, 393 and 494, 1866 (Pacific and Atlantic rivers of Panama); STEINDACHNER, Flussfische Südamerikas, I, 14, 1879 (Mamoni river near Chepo).

Rhamdia wagneri EIGENMANN & EIGENMANN, Proc. Cal. Acad., 2d Ser., I, 128, 1888 (Gorgona; Rio Chagres; Rio Obispo; Turbo; Atlantic Coast Cent. Am.; JORDAN & EVERMANN, Bull. 47, U. S. Nat. Mus., 1896, 150; EVERMANN & GOLDSBOROUGH, Bull. U. S. Fish Comm., 1902, 146 (Teapa and Frontera, Tabasco); MEEK, Fishes Mexico, 1904, 22 (Teapa and Frontera, Tabasco).

Rhamdia bransfordii GILL, Proc. Acad. Nat. Sci. Phila., 1876, 337 (Panama).

D. 7 to 9; A. 9 to 11; head 3.2 to 4.1; depth 4.7 to 5.5; eye 4.5 to 6.7 in the head, 1.8 to 4.3 in the interorbital; snout 2.1 to 3.1 in the head; distance from tip of snout to dorsal 2.5 to 2.9 in the body; base of adipose 2.5 to 3.2 in the body; maxillary barbel 1.3 to 2.1; mental barbels 3.1 to 6.

Numerous specimens; maximum length 28.9 cm. Specimens taken from a deeply shaded brook at Los Amates are of a much lighter color than those taken from the rivers of the same locality and the swamps a few miles from Puerto Barrios. This species was taken from swamps and eddies of streams. It was taken only from places where the bottoms are muddy.

The northernmost record of this species is Teapa and Frontera, Mexico, and the southernmost Chepo, Panama. Thus it apparently is strictly a Central American fish and is found on both the eastern and western slopes.

My specimens were taken from Rio Motagua, Algeria; Rio Kilagua, Los Amates; brooks and swamps, Los Amates; Rio Tenedores, Tenedores; swamps and streams two miles west of Puerto Barrios.

CHARACINIDÆ.

The Characinidæ are confined to Africa and South and Central America; a few species, belonging to five genera, have entered Middle America, one of them reaching the United States. They range southward to the Rio Negro, Patagonia, on the east and Puerto Mont, southern Chile, on the west.

Hemigrammus *Gill.*

Geographical distribution: Paraguay basin, Rio Grande do Sul, Rio San Francisco basin, Amazon, Orinoco, rivers of Trinidad, Rio Motagua basin and basin of Papaloapam.

2. **Hemigrammus compressus** *Meek.*

Hemigrammus compressus MEEK, Freshwater Fishes of Mexico, 87, 1904 (El Hule, Oaxaca, in the basin of the Papaloapam).

D. 9 to 11; A. 26 to 27; head 3.3 to 3.5; depth 2.5 to 2.7; snout 3.6 to 4.5 in head; eye 3 to 3.9 in head, .9 to 1 in interorbital; longest dorsal ray 1.1 to 1.3 in head; length of caudal peduncle 2.8 to 3.2 in head.

This species has been taken only at El Hule and Oaxaca in the Papaloapam basin by Meek, and at Los Amates in the Motagua basin by myself. My specimens were taken from swamps near Los Amates. The largest specimen is 3.9 cm. long. One taken Jan. 17, contains eggs.

Astyanax *Baird & Girard.*

Geographical distribution: all streams of the eastern slope of South

America north of Patagonia; Pacific slope from Peru to the Rio Motagua system and Mexico.

3. **Astyanax æneus** (*Günther*).

Tetragonopterus æneus Günther, Proc. Zoöl. Soc., 1860, p. 319; Günther, Cat. Fishes Brit. Mus., V, 326, 1864 (Oaxaca).

D. 10 to 11; A. 26 to 28; scales 7 to 8–35 to 37–6 to 8; head 3.8 to 4.1; depth 2.5 to 2.9; eye 3.1 to 4 in head; length of caudal peduncle 8.4 in body.

Numerous specimens; maximum length 11.6 cm. This species was taken in water varying from swift clear streams to swamps full of decaying matter. It is the most abundant of the species taken in Guatemala. Wherever other fish were found, except in brackish water, it was found. Of the specimens opened none contained mature eggs; the spawning season of this species is later than March, probably during the early part of the rainy season.

Specimens were taken from: Rio Motagua, El Rancho, Zacapa, Gualan; Rio Managua, Algeria; Rio Gualan, Gualan; Rio Kilagua, Los Amates; Rio Tenedores, Tenedores; swamps, Los Amates; Sulphur River, Puerto Barrios.

Brycon *Müller & Troschel.*

Geographical distribution: La Plata to the Rio Motagua basin, inclusive, in all streams. Western Peru, Ecuador, and Panama.

4. **Brycon dentex** *Günther.*

Brycon dentex Günther, Proc. Zoöl. Soc. Lond., 240, 1860 (Esmeraldas); E. & E., Proc. U. S. Nat. Mus., XIV, 1891, 55; Eigenmann, Proc. U. S. Nat. Mus., XVI, 56, 1893; Jordan & Evermann, Fishes of North and Middle America, I, 337, 1896; Boulenger, Boll. Mus. Torino, XIII, 3, 1898 (Rio Peripo).

Chalcinopsis dentex Günther, Cat. Fish. Brit. Mus., V, 337, 1864 (Esmeraldas; Rio Motagua; Rio Usumacinto; Yzabal); Gill, Proc. Phila. Acad. Sci., 188, 1877 (Lake Nicaragua).

D. 10 to 12; A. 28 to 37; scales 10–52 to 62–7 to 8; head 3.7 to 4.5; depth 2.9 to 3.9; eye, with adipose lid, 2.2 to 3.9 in the head, .9 to 1.7 in the interorbital; snout 3 to 4.5 in the head. The wide range of these measurements is due to the difference in the ages of specimens examined.

Specimens abundant; maximum length 42.4 cm. This species was not taken in swamps nor very sluggish streams. It seems to prefer rather swift, deep, clear water. Specimens taken March 3 had mature eggs. These are the largest strictly fresh-water fishes taken from the Motagua system. They go in schools similar to our suckers and in dynamiting

the rivers I was successful with only a few shots in getting any. With one charge I got a school of twenty or more three- to four-pound Machacas.

Localities: Rio Motagua, El Rancho, Zacapa, Gualan; Rio Gualan, Gualan; Rio Managua, Algeria; Rio Kilagua, Los Amates; Rio Tenedores, Tenedores; Rio Machaca near Tenedores; Sulphur River near Puerto Barrios; Brook near Los Amates.

GYMNOTIDÆ.

This family, consisting of about thirty species, is confined to the fresh-waters of tropical America. Only one species ranges into Middle America.

Gymnotus *Linnæus.*

Gymnotus Linnæus, Syst. Nat., ed. X, 246, 1858 (carapo).

Carapus Cuvier, Règne Animal, ed. I, 237, 1817 (in part); Müller & Troschel, Horæ Ichthyol., III, 13, 1845 (restricted to *fasciatus*) [not *Carapus*, Rafinesque].

Giton Kaup, in Duméril, Analyt. Ichth., 201, 1856 (*fasciatus*).

Type: *Gymnotus carapo* Linnæus.

Geographical distribution; Rio Motagua south to the Rio de la Plata.

5. **Gymnotus carapo** *Linnæus.*[1]

Carapo Marcgr., Hist. Pisc., 170; Willoughby, Hist. Pisc., 115, tab. G7, fig. 4.

Gymnotus Seba, Thesaur., III, tab. 32, fig. 1.

Gymnotus carapo Linnæus, Syst. Nat., ed. X, 246, 1858; ed. XII, 427, 1766; Bloch, V, 59, tab. 157, fig. 2.

Gymnotus fasciatus Pallas, Spicil. Zoöl., VII, 35; Schomburgk, Fishes of Guiana, 184, pl. 19, 1843 (Guiana).

Carapus fasciatus Cuvier, Règne Animal, ed. I, 237, 1817; Müller & Troschel, Horæ Ichthyol., III, 13, 1849; Castelnau, Anim. Amer. Sud, 85, 1855 (Amazon); Kaup, Apod., 139; Steindachner, Die Gymnotidæ, 13, 1868 (Caiçara; Cuyaba; Marabitanos; Surinam; Matto Grosso); Günther, Cat., VIII, 9, 1870 (Capin; Bahia; Surinam; British Guiana; Essequibo; Berbice; Trinidad; Is. Grenada; Rio Motagua); Hensel, Wiegm. Archiv, 89, 1870 (Guahyba; Porto Alegre); Cope, Proc. Am. Philos. Soc., 1870, 570 (Pebas); Cope, Proc. Acad. Nat. Sci. Phila., 1871 (1872), 257, (Ambyiacu); Lütken, Velhas Flodens Fiske, 247 and xix, 1875 (Rio das Velhas; Lagoa Santa and Rio San Francisco); Cope, Proc. Am. Philos. Soc., 1878, 682 (Peruvian Amazon); Boulenger, Proc. Zoöl. Soc., 1887, 282 (Canelos); Eigenmann & Eigenmann, Proc. U. S. Nat. Mus., XIV, 1891, 62; Perugia, Ann. Mus. Civico Storia Nat. Genova, 2nd Ser., X, 56, 1891 (Central Chaco); Eigenmann, Ann. N. Y. Acad. Sci., VII, 1894, 626 (Braret); Eigenmann, *l. c.*, 635 (Rio Grande do Sul); Cope, Proc. Am. Philos. Soc., 1894, 93 (Rio Grande do Sul); Boulenger, Boll. Torino, X, 3, 1895 (Colonia Risso and Villa Rica, Paraguay); Boulenger, Ann. Mus. Civico Genoa, 1898, 127 (Puerto, 14 de Mayo).

[1]This is not the *Sternopygus carapus* of Günther and other recent authors but their *Giton fasciatus*. The *carapus* of Günther et al, is the *Gymnotus macrurus* Bloch & Schneider.

Giton fasciatus KAUP in Duméril, Analyt. Ichthyol., 201, 1856; JORDAN & EVERMANN, Fishes North and Mid. Amer., 340, 1896 (Guatemala to Rio de la Plata); EIGENMANN & KENNEDY, Proc. Acad. Nat. Sci. Phila., 1893, 530 (Estancia, La Armonia; Campo Grande; Arroya Trementina); EIGENMANN & WARD, Proc. Wash. Acad. Sci., 177, 1905, pl. x, fig. 15.

Gymnotus albus PALLAS, Spicil. Zool., VII, 36 (Surinam); BLOCH & SCHNEIDER, 523, 1801.

Carapus albus KAUP, Apod., 140, 1856.

Gymnotus brachyurus BLOCH, Taf. 157, fig. I, 1787.

Gymnotus putaol LACÉPÈDE, Hist. Nat. Poiss., II, 176, 1800.

Gymnotus carapo BLOCH & SCHNEIDER, 521, 1801.

Carapus brachyurus CUVIER, Règne Animal, I, 237, 1817.

Carapus inæquilabiatus VALENCIENNES, in d'Orb. Voy. Am. Merid., Poiss., II, pl. xiv, 1847 (La Plata).

Body much elongate, its length 8.1 to 9.8 times its depth; head 8.2 to 10 in body; snout 2.8 to 8 in head; interorbital 2 to 2.7 in head; pectoral 2 to 2.7 in head.

Many specimens; females, taken about Feb. 20, with eggs; largest specimen 20 cm. I found them abundant in a deep pool in a small, very shady stream. The pool was well supplied with vegetable matter.

Localities: swamps and a small sluggish stream near Los Amates; swamps 2 to 4 miles west of Puerto Barrios.

PŒCILIDÆ.

A large family of fresh and brackish-water fishes of southern Europe, Africa, Asia, and America where they are especially abundant in the West Indies and Middle America. They range north to Cape Cod and south to the La Plata.

Rivulus *Poey.*

Geographical distribution: Cuba; United States; Central America and South America to Paraguay.

6. **Rivulus elegans** *Steindachner.*

Rivulus elegans STEINDACHNER, Denk. AK. Wien, XLII, 85, extr. p. 33, pl. vi, fig. 6, 1880; JORDAN, Proc. U. S. Nat. Mus., IX, 564, 1887; EIGENMANN, Proc. U. S. Nat. Mus., XIV, 64, 1891; GARMAN, The Cyprinodonts, 138, 1895.

D. 8; A. 12 to 13; scales 10–36 to 38; head 3.8 to 4.4 in body; depth 4.3 to 5.7; snout 3.2 to 7 in head; eye 2.8 to 4.6 in head, 1.5 to 2.2 in interorbital; least depth of caudal peduncle 1.4 to 2.2 in head; pectoral 1 to 1.5.

All my specimens were taken from brooks about Los Amates. Maximum length 5.3 cm.

Pseudoxiphophorus *Bleeker.*

Geographical distribution: Eastern slopes of Mexico from Jalapa to the Isthmus of Tehuantepec up to an altitude of 600 feet; Guatemala.

7. **Pseudoxiphophorus bimaculatus** (*Heckel*).

Xiphophorus bimaculatus HECKEL, SB. Akad. Wiss. Wien, 196, 1848 (Mexico).

Pseudoxiphophorus bimaculatus GÜNTHER, Cat., VI, 332, 1866; GARMAN, Mem. Mus. Comp. Zoöl., XIX, 1895, 81, pl. iii, fig. 6 (teeth), pl. viii, fig. 9 (male), (Mexico); WOOLMAN, Bull. U. S. Fish. Comm., 1894, 65 (Rio Blanca, Orizaba); JORDAN & EVERMANN, Bull. 47, U. S. Nat. Mus., 1898, 541 (Mirador); MEEK, Field Col. Mus. Pub. 65, 1902, 98 (Jalapa); MEEK, Fishes of Mexico, 127, 1904 (Jalapa, Xico, Cordoba, Otopa, Matzorongo, El Hule, Sanborn).

Pœcilioides bimaculatus STEINDACHNER, SB. Akad. Wiss. Wien, 1863, 176.

Pseudoxiphophorus reticulatus TROSCHEL, Müller's Reise Mexico, III, App. 638, 1865 (no locality); GÜNTHER, Cat., VI, 333, 1866; JORDAN & GILBERT, Synopsis, 344, 1883.

D. 10 to 17; A. 9 to 11; scales 9 or 10–28 to 30; head 3.2 to 4.1; snout 3 to 3.8 in head; eye 2.8 to 4.7 in head, 1.4 to 2.5 in interorbital; length of caudal peduncle 1.4 to 2.1 in head; depth 3.1 to 4.5 in body; anal ♂ 2 to 2.3 in body. Color varies from a light to a dark brown.

Many specimens; maximum length 8.8 cm. One female 8.8 cm., taken Feb. 7, contained 52 young .9 cm. long. All of my specimens were taken either from swamps or sluggish streams. Meek found it in swift streams.

Localities: irrigating ditch west of Gualan; swamps and their outlets 1 to 2 miles west of Puerto Barrios; brook and swamps near Los Amates.

Gambusia *Poey.*

Geographical distribution: Cuba; Guatemala north to the southern United States.

8. **Gambusia nicaraguensis** *Günther.*

Gambusia nicaraguensis GÜNTHER, Cat., VI, 336, 1866 (Lakes of Nicaragua); JORDAN & EVERMANN, Bull. 47, U. S. Nat. Mus. I, 682, 1898 (Lakes of Nicaragua).

D. 7 to 8; A. 10 to 11; scales 9–27 to 30; head 3.4 to 3.8; depth 3.8 to 3.6; snout 3 to 4 in the head; eye 2.7 to 3.5 in head, 1.3 to 2 in interorbital; least depth of caudal peduncle 1.4 to 1.7 in head; pectoral 1 to 1.1 in head; anal of males 3 to 3.3 in body. Color olivaceous; caudal dusky with or without bands of dots. The dots are usually in two vertical rows.

Number of specimens 25; maximum length 4.6 cm. Females taken Feb. 19, contain eggs which show no sign of young. My specimens were all taken from brackish water near Puerto Barrios.

Belonesox *Kner.*

Geographical distribution: Southern Mexico, Honduras, Lake Peten and rivers of Guatemala.

9. **Belonesox belizanus** *Kner.*

Belonesox belizanus KNER, SB. Akad. Wiss. Wien, 1860, 419 (Belize); GÜNTHER, Cat., VI, 33, 1866 (Mexico, Lago de Peten); JORDAN & GILBERT, Synopsis, 345, 1883; GARMAN, Mem. Mus. Comp. Zoöl., XIX 1895, 80 (Mexico); JORDAN & EVERMANN, Bull. 47, U. S. Nat., 18ϱ6, 684 (southern Mexico, Honduras and Guatemala); MEEK, Fishes of Mexico, 1904 (Boca del Rio, Otopa, El Hule, Obispo, Perez).

D. 9 to 11; A. 10 to 11; scales 15 to 17–40 to 52; head 2.7 to 3; depth 4.4 to 6.6; snout 1.3 to 2.1 in head; eye 4.8 to 6.6 in head, 1.2 to 1.6 in interorbital; upper surface of premaxillary 3 to 3.6 in head.

This species swims near the surface of the water. If disturbed, it dives down to come up a few feet away. It swims so close to the surface that in dynamiting I was able to stun only one sufficiently to procure it. As soon as the water is quiet after a charge, these fishes gather around to feed on the small fishes killed. When swimming near the surface, their eyes show like pearls against the dark water. The eyes are always first to attract the attention and sometimes they are seen distinctly when the rest of the fish is scarcely visible.

One female contained young 1.5 cm. long. Maximum length of female 15.4 cm.; male 11.5 cm. About 30 specimens. This species prefers swamps and the eddies of streams.

Localities: swamps east of Los Amates; swamps 2 miles west of Puerto Barrios; Rio Tenedores, Tenedores: Rio Managua, Algeria; Rio Negro, Tenedores.

Heterandria *Agassiz.*

Geographical distribution: Cuba and Mexico to the Amazon.

10. **Heterandria pleurospilus** (*Günther*).

Girardinus pleurospilus GÜNTHER, Cat., VI, 355, 1866 (Lago de Duenas); GÜNTHER, Fishes of Central America, 486, pl. lxxvii, fig. 1, 1869 (Lago de Duenas, Guatemala).

Heterandria pleurospilus JORDAN & EVERMANN, Bull. 47, U. S. Nat. Mus., 688, 18ϱ6 (Guatemala); MEEK, Fishes of Mexico, 148, 1904 (San Geronimo).

D. 7 to 8; A. 8 to 9; scales 7 to 8–28 to 29; head 4 to 4.3; depth 3.6 to 4.3; snout 3.5 to 4 in head; eye 3 to 4 in head, 1.4 to 2 in interorbital; depth of caudal peduncle 1.4 to 2 in head, 1.8 to 2.2 in its own length.

I found this species in a spring on the western slope at Santa Lucia.

11. **Heterandria lutzi** *Meek.*

Heterandria lutzi MEEK, Field. Col. Mus. Pub. 65, 1902, 106 (Oaxaca; Cuicatlan; Venta Salada); MEEK, Fishes of Mexico, 148, 1904, fig. 47 (Matzorongo; Otopa; El Hule; Perez; Tehuantepec).

D. 7 to 8; A. 8 to 9; scales 8½ to 9½–25 to 30; head 4 to 4.7, depth 3.1 to 3.7; snout 2.2 to 4.8 in head; eye 2.8 to 4.3 in head, 1.4 to 2 in interorbital; greatest depth of caudal peduncle 1.1 to 1.4 in the head; pectoral 1 to 1.2 in head; abdomen turns black in preserved specimens; 9 to 13 spots on sides; males about half the length of females.

These little fish were taken in abundance in sluggish streams and eddies. Females taken Jan. 13, have young almost ready to be born. Numerous specimens; maximum length 8.7 cm.

This species was taken from the Rio Motagua, Gualan; Rio Gualan, Gualan; Rio Managua, Algeria.

Pœcilia *Bloch & Schneider.*

Geographical distribution: West Indies, Mexico to Ecuador and Montevideo.

12. **Pœcilia sphenops** CUVIER & VALENCIENNES.

Pœcilia sphenops CUVIER & VALENCIENNES, Hist. Nat. Poiss., XVIII, 130, 1836 (Vera Cruz); GARMAN, Mem. Mus. Comp. Zoöl., 1895, 59, pl. iv, fig. 13 (Mexico and Central America); JORDAN & EVERMANN, Bull. 47, U. S. Nat. Mus. 694, 1896; MEEK, Fishes of Mexico, 153, fig. 49, 1904 (San Juan river, Monterey).

Molienesia fasciata MÜLLER & TROSCHEL, MB. Akad. Wiss. Berlin, 36, 1844 (Mexico).

Gambusia modesta TROSCHEL in Müller, Reise in Mexico, III, 639, 1865 (Mexico).

Gambusia plumbea TROSCHEL, *ibid.*, III, 640, 1865 (Mexico).

Pœcilia mexicana STEINDACHNER, SB. Akad. Wiss. Wien, 1863, 178 (southern Mexico); JORDAN & EVERMANN, Bull. 47, U. S. Nat. Mus., 1896, 692; BEAN, Proc. U. S. Nat. Mus., 1898 (Santa Maria, Vera Cruz).

Pœcilia limantouri JORDAN & SCHNEIDER, Bull. U. S. Fish Comm., 1900, 129, fig. 10 (Rio Tamesin, Tampico); JORDAN & EVERMANN, Bull. 47, U. S. Nat. Mus., 1900, 3153; MEEK, Field Col. Mus. Pub. 65, 1902, 106 (Puente de Ixtla; Balsas; La Antigua); FOWLER, Proc. Acad. Nat. Sci. Phila., 1903, 320 (Victoria, Tamaulipas).

D. 8 to 10; A. 8 to 9; scales 9 to 11–26 to 29; head 3.5 to 4.4; depth 2.8 to 3.4; snout 2.2 to 4.5 in head; eye 3.2 to 4.2 in head, 1.4 to 2.2 in interorbital; least depth of caudal peduncle 1.1 to 1.6 in head; pectoral 1 to 1.2 in head; anal of males 1.2 to 1.4 in head. Color dusky brown with cream colored under parts; these colors are uniform in about one-third of my specimens, in the remainder there is a dark or sometimes a golden spot on the base of each scale. These spots occur on the scales

from the dorsal down to the 5th or 7th row; some specimens have a dark caudal spot, others a profusely blotched caudal and others have their caudal plain or evenly dusky.

Many specimens; maximum length 11.4 cm. These fishes while taken from almost all of the streams were most abundant in the sluggish, mud-bottom streams. Females taken Feb. 10, have well developed young, 9 mm. long.

Localities: Rio Motagua, Zacapa, Gualan, El Rancho; Rio Gualan, Gualan; Rio Managua, Algeria; Rio Tenedores, Tenedores; spring, Santa Lucia, Brackish water and swamps two to five miles west of Puerto Barrios.

13. *Pœcilia amates* sp. nov.

(Fig. 1.)

Type no. 11375, I. U. Mus.; female; length 5 cm.; Los Amates.

Cotype; no. 11375a I. U. Mus.; male; length 3.6 cm.; Los Amates.

D. 8 to 9; A. 8 to 9; scales 8 to 10–26 to 28; head 3.1 to 3.9; depth 2.5 to 3.3; snout 3.4 to 4.5 in the head; eye 2.3 to 3.3 in the head, 1.1 to 2 in the interorbital;

Fig 1. *Pœcilia amates* sp. nov., nat. size.

least depth of caudal peduncle 1.1 to 1.8 in the head; pectoral 1 to 1.3 in the head; anal of males 2 to 2.2 in the body; body compressed and rather deep, more elongate in young; color obivaceous or dusky brown, lighter below; some specimens, especially the males have as many as 9 vertical lines on sides; vertical lines on females indistinct or none.

Description of a 3.5 cm. female; length of body 2.6 cm.; D. 8; A. 9; scales 9–27; head 2.2; depth 2.9; snout 4 in head; eye 2.7 in head, 1.3 in interorbital; least depth of caudal peduncle 1.6 in head; pectoral 1.1 in head. Body compressed and rather deep; profile to insertion of dorsal almost straight, very slightly raised just back of nape; from origin of dorsal to base of caudal concave; from anal to base of caudal very nearly straight; from tip of lower jaw to below middle of pectoral a uniform curve; head flat, wedge-shaped; snout square; premaxillary very protractile; lower jaw vertical, weak and projecting; maxillary not nearly to vertical from eye. Caudal peduncle long, its length 1.4 times its depth; eye rather large, nearer snout than to edge of opercle; pupil on level with tip of snout. Dorsal inserted midway between ventral and anal, its base short, 2 in the head, its rays 1.4 in head; caudal large, broad and rounded, its depth equal to its length; anal acute, inserted under middle of dorsal, its longest rays 1.4 in the head. Ventrals inserted under middle of pectorals, acute, their tips to base of anal. Pectorals almost to vertical from anal, slender and pointed; scales large; base of caudal scaled.

Color olivaceous; opercle reddish-brown; cheeks considerably pigmented; eye black; black spot above vent in most females. (Of a different species Jordan & Evermann say that this spot is a sign of pregnancy.) Dorsal black margined; pectorals plain; dorsal, caudal and anal somewhat dusky; black line from nape to dorsal, a similar line on lower edge of caudal peduncle.

The males are similar to the females with the following exceptions; the anal is modified into an intromittant organ equal to about half length of body; body of adult males deeper; caudal peduncle deeper and more compressed. General coloring the same; most males with from 3 to 9 vertical lines on sides.

Numerous specimens, all taken from a pond and its outlet at Los Amates. So abundant were these fishes at a little waterfall by a pond on Feb. 27, that I could scoop them up with my hands. Females with eggs, but of those examined the young had not begun to develop. My specimens were taken Jan. 17.

Xiphophorus *Heckel.*

Geographical distribution: Atlantic slope of Mexico and Guatemala.

14. **Xiphophorus helleri** *Heckel.*

Xiphophorus helleri Heckel, SB. Akad. Wiss. Wien, 1898, 163 (Rio Chisoy; Cordoba); Günther, Fishes Cent. Amer., 485, pl. 87, figs. 2–6, 1869 (Rio Chisoy); Garman Memoirs Mus. Comp. Zoöl., 1895, 68, pl. iv, figs. 14, teeth, pl. viii, fig. 4, male (Mexico and Central America); Jordan & Evermann, Bull. 47, U. S. Nat. Mus., 1896, 701; Meek, Fishes of Mexico, 157, 1904.

Xiphophorus helleri Var. Günther, Cat., VI, 350, 1866 (Rio Chisoy, Guatemala).

Xiphophorus güntheri Jordan & Evermann, Bull. 47, U. S. Nat. Mus. 1896, 702.

D. 12 to 15; A., in females, 8 to 10; scales 8 or 9–25 to 29; head 3.4 to 4.1; depth 2.5 to 3.7; snout 2.7 to 3.7 in head; eye 3.1 to 4 in the head, 1.2 to 2.7 in interorbital; least depth of caudal peduncle 4.3 to 6.2 in body.

Many specimens; maximum length, 11.5 cm.; maximum length of body of male 7.3 cm.; female 9.2 cm. Two females taken about March 1, contained well developed young. This species is found most abundantly in ponds, swamps and dark sluggish streams. Some were taken from eddies of swift streams.

Localities: irrigating ditch west of Gualan; Rio Managua, Algeria; brook and swamps near Los Amates; Rio Kilagua, Los Amates; Sulphur river, 3½ miles west of Puerto Barrios; Swamps 2 to 4 miles west of Puerto Barrios.

MUGILIDÆ.

Agonostomus *Bennett.*

Geographical distribution: freshwaters of the West Indies, eastern Mexico, Guatemala, and New Zealand.

15. **Agonostomus monticola** (*Bancroft*).

Mugil monticola Bancroft in Griffith's edition of Cuvier's Animal Kingdom, Fishes, 367, pl. 36, 1836.

Mugil irretitus Gosse, Nat. Sojourn Jamaica, 84, 1851 (Jamaica).

Agonostomus monticola Günther, Cat., III, 464, 1861 (West Indies and Mexico; Barbadoes).

Dajous monticola Cuv. & Val., XI, 164, pl. 316.

D. IV–I, 8; A. II–III, 9; scales 11 to 12–39 to 40; head 3.5 to 3.7; depth 3.8 to 4.1; snout 3.1 to 3.7 in head; eye 3.5 to 4.3 in head, 1 to 1.6 in interorbital.

Maximum length 12 cm. My 5 specimens were taken from swift water where the bottom is sandy.

Localities: Rio Motagua, El Rancho, Zacapa; Rio Tenedores, Tenedores; Rio Kilagua, Los Amates.

ATHERINIDÆ.

Thyrina Jordan & Culver.

Geographical distribution of the two known species: Pacific slope of Mexico and the Motagua system.

16. **Thyrina meeki** sp. nov.

(Fig. 2.)

Type: No. 11214 I. U. Mus.; length 11.5 cm.; Rio Motagua, Gualan.

D. IV–I, 9 to 11; A. I, 21 to 25; scales $9\frac{1}{2}$ or $10\frac{1}{2}$–39 to 43; head 3.9 to 4.9;

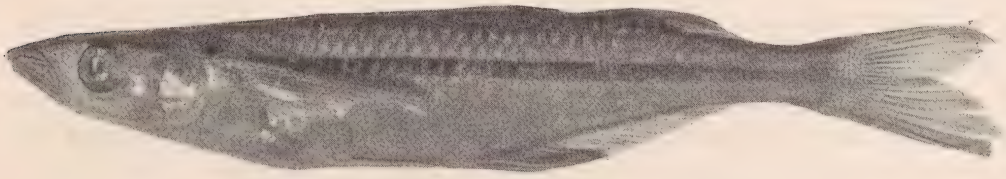


Fig. 2. *Thyrina meeki* sp. nov., about nat. size.

depth 5.1 to 6.6; snout 2.9 to 3.7; eye 3.1 to 4.6 in the head 1 to 1.6 in the interorbital; base of anal 3.2 to 3.7 in the body.

Description of a 10-cm. specimen. Body 8.4 cm. long; D. IV–I, 9; A. I, 23; scales $10\frac{1}{2}$–42; head 4.7; depth 6.6; snout 3 in head; eye 3.6 in head, 1 in interorbital; anal 3.6 in body. Body very slender, compressed; top of head flat; back little higher than head; sides above anal strongly compressed; sides of belly converging uniformly; breast compressed to an edge; caudal peduncle long, its least depth 2.4 in its length; sides of head compressed; chin steep; mouth rather large; jaws

decurved; recurved canine-like teeth in each jaw; teeth in more than one series; teeth on maxillary; premaxillary protractile; eye large, nearer tip of snout than to edge of opercle; pectoral inserted high, its base long, 3.5 in its length, pointed, its tip reaching verticle from vent; ventrals midway between tip of snout and insertion of rayed dorsal, short and subtruncate, reaching but little past vent. Anal inserted before verticle from intersertion of spinous dorsal, its margin falcate and its longest rays 1.5 in the head; caudal deeply forked, the lower lobe the larger (which is usually the case in this species); rayed dorsal over last half of anal; spinous dorsal weak, its longest spine about 3 in the head, its origin equidistant between edge of opercle and base of anal; base of anal scaled.

Color translucent greenish; edges of scales granular pigmented; pigmented streak at base of anal; dark lateral line about the width of the pupil; top of head darker than body; iris plumbeous; pectorals and ventrals pale; anal margined with dusky; both rayed and spinous dorsals clouded; caudal a little dusky.

Rivers, especially where the water is swift, and the bottom either sandy or rocky. Abundant in the Motagua river. Maximum length 11.4 cm.; females with eggs. Many specimens.

This species is named in honor of Dr. S. E. Meek of the Field Columbian Museum, for his work on the fishes of Mexico.

Localities: Rio Motagua, El Rancho, Zacapa, Gualan; Rio Managua, Algeria, Rio Kilagua, Los Amates; Rio Tenedores, Tenedores; Rio Gualan, Gualan.

GOBIIDÆ.

Philypnus *Cuvier & Valenciennes.*

Geographical distribution: Both slopes of Middle America.

17. **Philypnus dormitor** (*Lacépède*).

Gobiomorus dormitor Lacépède, Hist. Nat. Poiss., II, 599, 1789; Martinique.

Philypnus dormitor Girard, Mex. Bound. Surv., 29, pl. xii, fig. 13, 1859 (mouth of the Rio Grande); Gill, Proc. Acad. Nat. Sci. Phila., 1860, 122 (mouth of the Rio Grande); Jordan & Evermann, Bull. 47, U. S. Nat. Mus., 1898, 2194; Jordan & Synder, Bull. U. S. Fish Comm., 1900, 147 (lagoons near Tampico); Meek, Field Col. Mus. Pub. 65, 1902, 120 (La Antigua); Meek, Fishes of Mexico, 226, 1904 (Mexico).

Philypnus lateralis Gill, Proc. Acad. Nat. Sci. Phila., 1860, 123 (Cape San Lucas); Jordan, Proc. Cal. Acad. Sci., 1895, 493 (Rio Presidio and Astillero); Rutter, Proc. Cal. Acad. Sci., 1896, 264 (fresh waters at San Jose del Cabo, Lower California); Jordan & Evermann, Bull. 47, U. S. Nat. Mus., 1898, 2195 (Rio Presidio, near Mazatlan, Mexico).

Eleotris dormitatrix Günther, Cat., III, 119, 1861 (Mexico).

Gobiomorus dormitator Bean, Proc. U. S. Nat. Mus., 1898, 542 (Dominica and Santa Maria, Vera Cruz).

Two specimens; maximum length 40 cm.

Locality: Rio Tenedores, Tenedores; Sulphur River, Puerto Barrios.

Awaous *Steindachner.*

Geographical distribution: both slopes of Middle America south to the Rio Dulce and Ecuador.

18. **Awaous taiasica** (*Lichtenstein*).

Amore guacu Marcgrave, Hist. Brasil, 166, 1648 (Brazil).

Gobius taiasica Lichtenstein, Berl. Abhandl., 273, 1822 (Brazil), not *Tajasica* Marcgrave.

Chronophorus taiasica Jordan & Eigenmann, Proc. U. S. Nat. Mus., 1886, 500; Meek, Fishes of Mexico, 233, 1904 (Cuantla; Valles; San Francisco; Perez).

Awaous taiasica Jordan, Proc. Cal. Acad. Sci., 1895, 494 (Rio Presidio, Mazatlan; San José del Cabo, Lower California); Jordan & Evermann, Bull. 47, U. S. Nat. Mus., 1898, 2236; Rutter, Proc. Cal. Acad. Sci., 1896, 265 (Rio San José, San José del Cabo, Lower California); Jordan & Synder, Bull. U. S. Fish Comm., 1900, 147 (Rio Ixtla, Puente de Ixtla); Meek, Field Col. Mus. Pub. 65, 1902, 121 (La Antigua; Balsas; Puente de Ixtla).

Gobius banana Cuvier & Valenciennes, Hist. Nat. Poiss., XII, 103, 1837 (San Domingo); Günther, Cat., III, 59, 1861.

Gobius martinicus Cuvier & Valenciennes, Hist. Nat. Poiss., XII, 105, 1837 (Martinique).

Chronophorus bucculentus Poey, Memorias de Cuba, II, 275, 1861 (Cuba).

Rhinogobius contractus Poey, Memorias de Cuba, II, 424, 1861 (Cuba); Poey, Enumeratio, 125, 1875.

Gobius dolichocephalus Cope, Trans. Amer. Philos. Soc., 1869, 403 (near Orizaba, Mexico).

Euctenagobius latus O'Shaughnessy, Ann. Mag. Hat. Hist., Ser. 4, XV, 1875, 146 (Bahia, Coll. Dr. Wucherer).

Many specimens; maximum length 19 cm.

Localities: Rio Gualan, Gualan; Rio Motagua Gualan; Rio Managua, Algeria; Rio Kilagua, Los Amates, Sulphur River, Puerto Barrios.

CICHLIDÆ.

Tropical American waters harbor about 25 genera with about 250 species. The genera *Heros* and *Cichlasoma*, by some considered a single genus, have reached a great development in Central America. *Heros* has reached Cuba where a number of incipient species are found.

Cichlasoma *Swainson.*

This genus contains those species allied to *Astronotus*, which have 4

to 11 spines in the anal fin, the dorsal and anal not closely scaled and the lower lip interrupted mesially to form a frenum. Species very numerous.

Geographical distribution: Mexico to the La Plata, on both slopes of Central America. Species few in South America.

19. **Cichlasoma spilurum** *Günther.*

(Fig 3.)

Heros spilurus Günther, Cat., IV, 289, 1862 (Guatemala); Günther, Fishes of Central America, 451, pl. lxxiii, fig. 1, 1868 (Rio Motagua, Yzabal).

Cichlasoma spilurum Jordan & Evermann, Fishes of Middle and North America, II, 1520, 1898 (Rio Motagua, Guatemala); Pellegrin, Étude Cichlides, 186, 1904 (L. Mullins, Guatemala).

D. XVII or XVIII, 9 to 11; A. VIII or IX, 7 to 9. Scales 5 to 6–27 to 30–12 to 13; head 2.8 to 3.2; depth 1.7 to 2.6; snout 2.2 to 3 in head; eye 2.4 to 4 in head, 1 to 1.9 in interorbital; greatest depth of caudal peduncle 1.7 to 2.4 in head; pectoral 1 to 1.3 in head. Color of mature specimens dark, ashy gray, with 7 more or less distinct vertical bars; young lighter, with more distinct vertical bars.

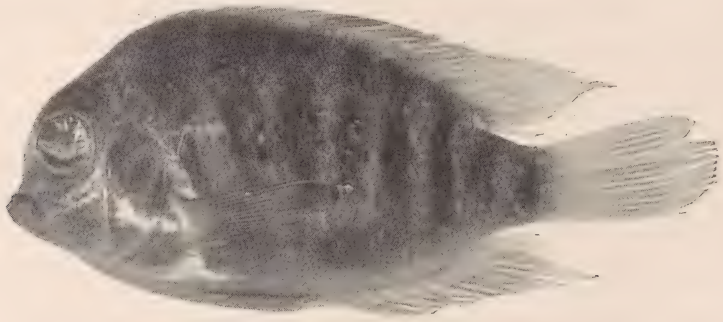


Fig. 3. *Cichlasoma spilurum* Günther, nat. size.

The fins of this species are very fragile and the dorsal and anal filaments are often broken off. Some specimens have the dorsal filament produced in a mere thread to tip of caudal.

Numerous specimens; maximum length 11.6 cm. Abundant in Sulphur and Tenedores Rivers.

Localities: Rio Motagua, Rio Gualan, and irrigating ditch, near Gualan; Rio Managua, Algeria; Rio Kilagua, Los Amates; Rio Tenedores, Tenedores; swamp stream 2 miles west of Puerto Barrios; Sulphur River 3½ miles west of Puerto Barrios.

The following is a description of a unique specimen taken from the Rio Tenedores, Tenedores, Feb. 9. It is a new genus if it is not a deformed *Cichlasoma spilurum.*

Total length 7.9 cm. length of body 6 cm. D. XVII, 10; A. VIII, 8; scales 6–29–13; head 3; depth 1.9; snout 2.9 in the head; eye 3.3 in the head; 1.3 in the interorbital; least depth of caudal peduncle 2.5 in the head, 1.3 in its own depth; pectoral 1 in the head. First dorsal spine 3.3 in the last, last 2 in the head; 1st anal spine 2.2 in the last, the last 2.2 in the head. Body compressed; profile from the interorbital to insertion of dorsal very slightly concave; back not strongly arched; forehead almost vertical; interorbital almost flat; ventral outline convex to end of anal; peduncle thin, its edges converging; length of head about equal to its depth; eye large, situated above and anterior to centre of head, much above horizontal from tip of snout; mouth small, upper jaw weak; maxillary to vertical from eye; mandible projecting, Teeth in bands in both jaws, the outer brown and enlarged; lips thin, the lower with a frenum. Dorsal inserted anterior to gill-openings, its spine rather high, its longest rays slightly filamentous and reaching to near middle of caudal; caudal rather long, little rounded; anal inserted under 12th dorsal spine, its spines long, its longest rays to first third of caudal; ventrals inserted posterior to base of pectoral, 2nd ray produced to base of 4th anal spine; pectorals long and narrow reaching to tips of ventrals.

Color olivaceous with 7 dark vertical bands and a dark caudal spot; opercle somewhat brownish; iris black; fins except the pectorals a little dusky.

20. **Cichlasoma hedricki** *Meek.*

Cichlasoma hedricki MEEK, Fresh-water Fishes of Mexico, 208, 1904, fig. 66 (rivers of Mexico, south of Vera Cruz).

D. XVIII to XX, 9 to 10; A. VIII to X, 7 to 9; scales 5 to 6–27 to 32–12 to 14; head 2.6 to 3; depth 2.2 to 2.5; snout 3.1 to 4 in the head; eye 3.2 to 5.7 in the head; 1 to 1.9 in the interorbital; greatest depth of caudal peduncle 2.1 to 2.5 in the head. Color varies from a dark bluish tinged brown to a light olive in which the bands and bars of darker color show distinctly.

Some of my specimens have dark specks on opercles and cheeks, while two have bluish dots scattered over head and body above lateral line to tip of pectoral.

Twenty-two specimens; maximum length 13.8 cm. Taken from swamps or sluggish streams and the Kilagua River.

Localities: Rio Kilagua, and brook near Los Amates; Rio Negro, Tenedores; swamps and swamp streams 2 to 3 miles west of Puerto Barrios.

21. **Cichlasoma globosum** sp. nov.

(Fig. 4.)

Type: No. 11382 I. U. Mus.; length 22 cm.; brackish water, Puerto Barrios.

D. XVI to XVII, 13; A. VI, 9 or 10; scales 6 or 7–32 or 33–13 or 14; head 2.8 to 3; depth 1.8 to 1.9; snout 2.1 to 2.3 in head; eye 4.2 to 5 in head, 1.8 to 2.1 in interorbital; greatest depth of caudal peduncle 1.6 to 2.4 in head; pectoral 1.1 to 1.3; color varies from a dark slaty-blue to a smoky brown.

Description of a 22 cm. specimen; length of body 16.2 cm.; D. XVI, 13; A. VI,

9; scales 7–32–13; head 2.8; depth 1.8; snout 2.3 in head; eye 4.8 in head, 2.1 in interorbital; greatest depth of caudal peduncle 1.8 in head; pectoral 1.2; profile to nape slightly concave and steep; a depression in the interorbital; nape to end of dorsal gently arched; belly straight; body deep, not much elongate, compressed; peduncle short and deep, its length 2 in its depth, much compressed; head higher than long; interorbital convex with a slight depression; snout rather long, acute; lips fleshy, the lower with a frenum; premaxillary protractile; maxillary almost entirely hidden under the preorbital; teeth in bands in both jaws, the outer enlarged,

Fig. 4. *Cichlasoma globosum* sp. nov., about ¼ nat. size.

conical and brown-tipped; mouth horizontal; maxillary not nearly to vertical from eye; preorbital equal to distance from eye to upper edge of opercle; lower edge of orbit above centre of head; eye rather large, 1.3 times length of maxillary; nares much closer to tip of snout than to eyes; origin of dorsal anterior to base of pectoral, first spine 5 in last, last spine 1.8 in head; rayed dorsal high, produced past middle of caudal, the longest rays a little longer than head; caudal long, strong, broad and slightly rounded; origin of anal under origin of rayed dorsal; anal spine very strong, first 3.5 in the last, last 1.8 in head; rayed anal acute, produced past middle of caudal, its longest ray slightly less than head, ventral insertion posterior to base of pectoral, 1st ray produced into a filament to 4th anal spine; pectoral long, obtuse, its tip to vertical from base of first anal spine.

Scales large and ctenoid; base of anal, caudal and dorsal scaled; 6 rows on cheeks; 5 on opercle.

Color deep slaty-blue over entire body except breast and under parts of head which are a little lighter; large black caudal spot; pectoral pale; dorsal, anal and ventral deep slaty-blue; caudal lighter, with a fleshy tinge; dark spots on rayed dorsal and caudal, those on rayed dorsal more or less in bands.

Locality: mouth of small stream at edge of Puerto Barrios.

22. **Cichlasoma mañana** sp. nov.

(Fig. 5.)

Cichlasóma maculicauda Regan, Ann. and Mag. Nat. Hist. (7), XVI, 227, 1905.

Type No. 11385 I. U. Mus. length 20 cm.; Tenedores River, Tenedores.

D. XVI or XVII, 12 to 14; A. VI, 9 to 10; Scales 6 or 7–21 to 33–13 or 14; head 2.8 to 3 in body; depth 1.8 to 2.1; snout 2.1 to 3.1 in head; eye 3.4 to 5 in head

1.2 to 2.2 in interorbital; greatest depth of caudal peduncle 1.6 to 2.4 in head; pectoral 1.1 to 1.3 in head; color dark slaty; ventral parts not much lighter; five indistinct vertical bars can be made out on some specimens while on others only one bar at tip of pectoral; large black caudal spot.

Description of a 20 cm. specimen; length of body 15.2 cm. D. XVII, 13; A. VI, 10; scales 7–32–13; head 3; depth 2.1; snout 2.4 in head; eye 5 in head, 2.1 in interorbital; greatest depth of peduncle 1.8 in head; pectoral 1.3 in head; body

Fig. 5. *Cichlasoma mañana* sp. nov., about ½ nat. size.

rather deep, compressed; belly as much below head as back is above; caudal peduncle deep and strong, its depth equal to its length; head little longer than high; profile to nape steep, from nape to end of dorsal a uniform curve; belly straight; snout blunt; mouth horizontal and terminal; lips rather fleshy, the lower with a frenum; teeth in bands, the outer enlarged, brown-tipped and slightly recurved; maxillary not near to vertical from anterior margin of orbit; eye moderate, above centre of head; dorsal inserted over insertion of pectoral; rayed dorsal a little past fourth of caudal, first spine 6.5 in last, last 2 in head; anal inserted under 14th dorsal spine; first anal spine 3.4 in last, last 1.9 in head; rayed anal to middle of caudal; ventral produced in a filament past vent, almost to anal; pectoral rather broad and obtuse, its tip past vertical from tip of ventral spine; caudal large, strong and almost truncate or slightly rounded; scales ctenoid, large, 5 rows on cheeks; small scales on bases of dorsal, caudal and anal.

Color a blackish-slate, with four faint, darker vertical bars, the bar at tip of pectoral much more distinct than the rest; a large black area behind and below tip of pectoral; large black caudal blotch; no lateral streak; pectoral pale; rest of fins dusky; dark spots on dorsal, anal and caudal arranged in more or less irregular rows.

Specimens 13; maximum length 22 cm. These fishes readily jump the seine. When not disturbed they seem simply to loiter about the banks at a depth of about 2 feet. For this lazy swimming habit I have given them the name Mañana.

Localities: Rio Managua, Algeria; Rio Kilagua, Los Amates; Rio Tenedores, Tenedores.

23. **Cichlasoma acutum** sp. nov.

(Fig. 6.)

Type: No. 11186 I. U. Mus.; length 16.5 cm.; Rio Tenedores, Tenedores.

D. XV or XVI, 11 to 13; A. VI or VII, 8 to 10; Scales 5 to 7–29 to 33–12 to 14; head 2.4 to 2.7 in body, depth 2 to 2.3 in body; snout 2 to 2.9 in head; eye 3.3 to 5 in head, 1 to 1.7 in interorbital; greatest depth of caudal peduncle 2.1 to 2.5 in head; pectoral 1 to 1.3 in head.

Description of a 12.6 cm. specimen; length of body 9.7 cm.; D. XVI, 11; A. VI, 9; scales 6–30–13; head 2.2; depth 2.1; snout 2.1 in head; eye 4.2 in head, 1.7 in interorbital; greatest depth of caudal peduncle 2.1 in head; pectoral 1.1 in

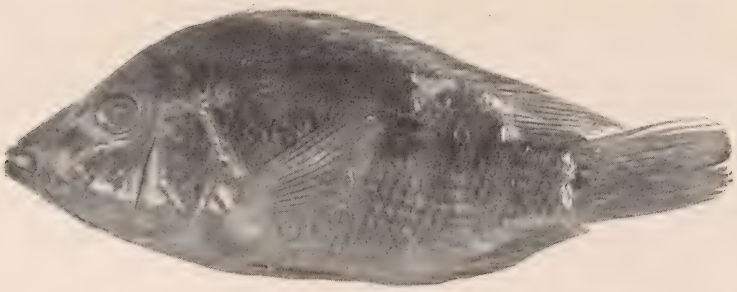


Fig. 6. *Cichlasoma acutum* sp. nov., about ⅔ nat. size.

head; body elongate, compressed; back high; profile to nape straight, thence but little arched; ventral outline, including ventrals when folded, a uniform curve from tip of snout to caudal peduncle; peduncle strong and deep, its length 1.8 in its depth; head longer than high; snout pointed; mouth terminal slightly oblique, moderate in size, lower jaw strong; lip with frenum; maxillary not to eye; hid beneath the preorbital, its length equals the distance from its tip to eye; teeth in series, the outer enlarged and canine-like; premaxillary protractile; lips fleshy; nares equidistant between tip of snout and eyes; cheeks slightly compressed with 4 rows of scales; eye rather large, high and nearer edge of opercle than to tip of snout, inserted anterior to vertical from base of pectoral; first spine of dorsal 2.7 in last, the last 2.3 in head; rayed dorsal produced almost to middle of caudal; caudal long, broad, strong, subtruncate; origin of anal under 13th dorsal spine; rayed portion to first third of caudal; first anal spine 1.9 in last, last 2.2 in head; tip of ventral reaching 2nd anal spine; origin of ventral posterior to base of pectoral; pectoral large, long and subacute, its tip to vertical from 3rd anal spine.

Color a dark olive-brown with eight slightly darker vertical bars; a large black blotch at end of pectoral which is one of the series on the vertical bars from opercle to end of dorsal; snout and interorbital bluish; an indistinct dark band between the eyes, another on snout connecting the eyes; iris plumbeous, a small black caudal blotch; black dots on opercles and cheeks; opercle very dusky with a brownish tinge; a small black spot on base of pectoral, otherwise pale; small dark spots on caudal fin, those on dorsal arranged in at least seven vertical rows across the rays and posterior part of spinous portion; ventrals and anal dusky as are all the fins except the pectorals.

About 40 specimens, the largest 16.5 cm. long. This species seems to prefer rather swift and clear water where there are plenty of rocks and sandy bottom. The clean cut features of this fish are of interest; its sharply acute fins, the large and strong caudal, its sharp triangular head and the general outlines of dorsal and ventral parts gives it the appearance of a game fish.

Females with immature eggs.

Localities: Rio Motagua, Algeria; Rio Kilagua, and brook, Los Amates; Rio Tenedores, Tenedores.

24. **Cichlasoma nebuliferum** (*Günther*).

Chromis nebulifer GÜNTHER, Proc. Zoöl. Soc., 1860, 318.

Heros nebulifer GÜNTHER, Cat., IV, 297, 1862 (Mexico).

Cichlasoma nebuliferum JORDAN & EVERMANN, Fishes Middle and North America, II, 1524, 1898 (Mexico); PELLEGRIN, Étude Cichlides, 180, 1898 (Mexico).

Heros intermedius GÜNTHER, Cat., IV, 298, 1862 (Guatemala); GÜNTHER, Fishes Cent. Am., 468, pl. lxxviii, fig. 1, 1868 (Lake Peten).

Cichlasoma intermedium JORDAN & EVERMANN, Fishes Middle and North America, II, 1517, 1898 (Lake Peten); PELLEGRIN, Étude Cichlides, 173, 1904 (Rio Polachic, Guatemala).

Heros angulifer GÜNTHER, Cat., IV, 298, 1862 (Guatemala); GÜNTHER, Fishes of Central America, 469, pl. lxxxv, fig. 1, 1868 (Yzabal).

Cichlasoma anguliferum JORDAN & EVERMANN, Fishes of Middle and North America, II, 1517, 1898 (Guatemala).

Acara rectangularis STEINDACHNER, Chromiden Majicos und Cent. Amerikas, Tab. 1, fig. 1, 1864 (Mexico).

Cichlasoma rectangulare JORDAN & EVERMANN, Fishes Middle and North America, II, 1515, 1898 (Mexico); MEEK, Fishes Mexico, 216, 1904 (Mexico); PELLEGRIN, Étude Cichlides, 169, 1904 (Mexico).

Cichlasoma intermedium, nebuliferum and *rectangulare* differ from all other species of this genus in their peculiar coloration, which consists of a dark band from the gill-opening to below the posterior part of the spinous dorsal where it turns up at or nearly at a right angle to the dorsal where the spinous and rayed portions meet.

Steindachner described a specimen of *Acara* (*Acara* = *Cichlasoma*) *rectangularis* 7½ inches long from Mexico without naming definitely the locality. It was not found by Meek in his extensive expeditions in Mexico. Günther described *Heros intermedius* from three specimens, 5 to 6 inches long, taken from Lake Peten, and his *Heros angulifer* from 2 specimens 4 inches long taken from Lake Yzabal. No additional specimens have been recorded.

The data for these specimens are as follows: *rectangulare,* D. XVI, 13; A. IV, II; scales 4–33–13; *intermedium,* D. XVII to XVIII, II; A. V or VI,

8 to 10; scales 5–32–13. My specimens D. XVI to XVIII, 12 to 15; A. V, 9 to 11; scales 5–31 to 35–12 or 13. Pellegrin, on examining Günther's specimens without additional material, considered his two species identical.

I have 16 specimens, ranging from 6.5 cm. to 20. cm. All of these were taken from Sulphur River, the only place where I found this species. I have no doubt that these specimens represent Günther's species. The small number of anal spines is the only character so far noted that in any way distinguishes *rectangulare* as a distinct species and this does not seem to be sufficient.

D. XVI to XVII, 12 to 15; A. V, 9 to 11; scales 5 to 6–31 to 35–12 to 13; head 2.6 to 3; depth 2.1 to 2.5; snout 2.3 to 3.4 in head; eye 3.1 to 5.2 in head, 1 to 2 in interorbital; greatest depth of caudal peduncle 2.1 to 2.3 in the head.

Color varies from a dull brown (in young) with pale ventral parts to a dark brown more or less tinged with blue; in specimens 18 cm. long the ventral region is as dark as the back; specimens of this size have considerable blue, especially about the gills ventrally; a dark lateral band extending almost to the black caudal spot; large, black humeral blotch; one large black band or as many as three smaller ones from the lateral band up to and on the basal parts of the rayed and spinous dorsal; these bands in 18 cm.-specimens also extend down to the anal. Some specimens under 9 cm. do not have the black humeral spot, only the broad lateral band.

Taken only from Sulphur River, $3\frac{1}{2}$ miles west of Puerto Barrios. These fishes swim leisurely among the rocks and about trash until disturbed, when they dart off to deep water or places of concealment. Females taken March 2, have fully developed eggs. Length of largest specimen 18.7 cm.

Heros *Heckel.*

Geographical distribution: Cuba, Mexico, both slopes of Central America, and south to the La Plata basin. Species few in South America.

25. **Heros friederichsthalii** *Heckel.*

Heros friedrichsthalii Günther, Cat., IV, 294, 1862 (Lake Peten); Jordan & Evermann, Fishes Middle and North America II, 1528, 1898 (Lake Peten and Lake Nicaragua with its outlet Rio San Juan); Günther, Fishes of Central America, 459, 1868 (Lake Peten).

Heros motaguensis Günther, Fishes of Central America, 462, pl. lxxvii, fig. 2, 1868 (Guatemala); Jordan & Evermann, Fishes of Middle and North America, II, 1534, 1898 (Rio Motagua and Lake Nicaragua); Pellegrin, Étude Cichlides, 198, 1904.

Heros managuensis Günther, Fishes of Central America 463, pl. lxxvii, fig. 3, 1868 (Lake Managua); Jordan & Evermann, Fishes of Middle and North America, II, 1533, 1898 (Lake Managua, Nicaragua).

D. XVII to XIX, 10 to 12; Anal VI to VIII, 8 to 9; scales 5 or 6–30 to 33–11 to 12; head 2.4 to 2.7; depth 2.4 to 2.9; snout 2.4 to 3.6 in head; eye 3.8 to 5.8 in

head, 1 to 1.8 in interorbital; greatest depth of caudal peduncle 2.1 to 2.7 in head; pectoral 1.5 to 1.7 in head.

Color variable, the darker specimens slaty-blue and the lighter ones dusky-brown; ten vertical bars and a dark caudal spot. In one specimen the color is a light brown with the vertical bars jet black. Some specimens have dark spots on vertical fins arranged more or less in rows.

Of the specimens examined the females are the darker, thicker, and apparently stouter in body proportions than the males. The females have been described as the species *Heros managuensis*, and the males as *Heros motaguensis*.

Twenty specimens; maximum length 32 cm. This species has the appearance of a game fish and they take the hook readily. One female taken Feb. 10, has well developed eggs.

Localities: Rio Motagua and Rio Gualan; Rio Managua, Algeria; Rio Kilagua, Los Amates; pond near Los Amates; Rio Tenedores, Tenedores.

26. **Heros salvini** *Günther.*

Heros salvini Günther, Cat., IV, 294, 1862 (Rio de Santa Isabel, Lake Peten); Günther, Fishes Cent. Amer., 460, pl. lxxiii, fig. 3, 1869; Jordan & Evermann, Bull. 47, U. S. Nat. Mus., 1898, 1528.

Cichlasoma salvini Meek, Fresh-water Fishes of Mexico, 207, 1904 (southern Mexico and Guatemala, Motzorango; Refugio; El Hule; Perez; Obispo).

D. XVI to XVII, 10 to 12; A. VI to IX, 8 to 9; scales 5 to 7–26 to 31–10 to 11; head 2.4 to 2.6; depth 2.3 to 2.5; snout 2.8 to 3.4; eye 3.4 to 4.6 in head, .9 to 1.4 in interorbital; greatest depth of caudal peduncle 2.2 to 2.7 in head.

Seventeen specimens, Sulphur River; the largest 12.4 cm.; females taken March 4, contained eggs. Sulphur river is fed by a hot spring and some of the specimens were taken where the water was 90° F. and so strongly sulphurous that it can be detected more than a hundred yards away.

27. **Heros microphthalmus** *Günther.*

Heros microphthalmus Günther, Cat., IV, 295, 1862 (Guatemala); Günther, Fishes of Central America, 464, 1868 (Rio Motagua); Jordan & Evermann, Fishes Middle and North America, II, 1536, 1898 (Rio Motagua and Nicaragua); Pellegrin Étude Cichlides, 196, 1904 (Rio Motagua).

D. XVII to XVIII, 12 to 14; A. V to VII, 8 to 11; scales 5 to 6–27 to 36–12 to 15; head 2.9 to 3.2; depth 2.1 to 2.6; snout 2 to 2.4 in head; eye 3.8 to 5.3 in head, 1.4 to 2.2 in interorbital; greatest depth of caudal peduncle 1.8 to 2.2 in head; pectoral 1.2 to 2.1 in head.

Color varies from a dusky-brown in young to a slaty-blue in adults. Some specimens have as many as 6 vertical bars and a black caudal spot. These markings are not usually so prominent in specimens over 12 cm.

Thirty specimens; the largest 21 cm. long. A female taken Jan. 14, has well developed eggs. Taken for the most part in swift, clear water where the bottom was sandy and rocky.

Localities: Rio Motagua, El Rancho, Zacapa, Gualan; Rio Managua, Algeria; Rio Kilagua, Los Amates; Rio Tenedores, Tenedores.

Thorichthys *Meek.*

Geographical distribution: Eastern slope of Mexico and Central America.

28. **Thorichthys helleri** (*Steindachner*).

Heros helleri STEINDACHNER, Chromiden Mexicos, 1864, 8 (Rio Teapa, Tabasco, Mexico).

Cichlasoma helleri JORDAN & EVERMANN, Bull. 47, U. S. Nat. Mus., 1896, 1521.

Thorichthys helleri MEEK, Fresh-water Fishes of Mexico, 223, 1905 (lowland streams of Mexico which empty into the Gulf south of the City of Vera Cruz; Otopa; El Hule; Obispo; Perez; San Juan Evangelista).

Heros maculipinnis STEINDACHNER, Chromiden Mexicos, 1864, 13 (Rio Zanopa, Mexico); BEAN, Proc. U. S. Nat. Mus., 1892, 541 (Santa Maria, Vera Cruz); JORDAN & EVERMANN, Bull. 47, U. S. Nat. Mus. 1898, 1529.

D. XVI, 10; A. VII to VIII, 7 to 9; scales 6 to 7–29 to 31–14; head 2.8 to 2.9; depth 2 to 2.1; snout 2.4 to 2.8 in head; eye 3.1 to 3.4 in head, 1 in interorbital; greatest depth of caudal peduncle 2 to 2.1 in head; pectoral 2.8 to 3 in body.

Three specimens; maximum length 15.4 cm. One specimen from Rio Negro, a dirty swamp stream at Tenedores, the other two from $3\frac{1}{2}$ miles west of Puerto Barrios in Sulphur River, a clear, swift stream.

29. **Thorichthys ellioti** *Meek.*

Thorichthys ellioti MEEK, Fresh-water Fishes of Mexico, 223, 1905, fig. 72.

D. XV to XVI, 9 to 12; A. VII to VIII, 7 to 9; scales 6 to 7–29 to 33–13 to 14; head 2.8 to 2.2 in body; depth 2 to 2.4 in body; snout 2.2 to 3 in head; eye 3 to 3.8 in head, 1 in interorbital; greatest depth of caudal peduncle 1 to 2.1 in head.

Color dark olive above axis of body, much lighter below; dark spots on head.

Taken only in swift water with either sandy or rocky bottom. Maximum length 16.6 cm.; females with eggs.

Localities: Rio Motagua, Zacapa, Gualan; Rio Managua, Algeria; Rio Kilagua, Los Amates; Rio Tenedores, Tenedores; Rio Gualan, Gualan.

CENTROPOMIDÆ.

Species all American, marine, entering streams. One species found in the rivers of southeastern Mexico far above tidewater. My specimens of this family were taken some 14 miles from the coast.

Centropomus *Lacépède.*

30. **Centropomus mexicanus** *Bocourt.*

Centropomus mexicanus Bocourt, Ann. Sci. Nat. Paris, 90, 1868 (Gulf of Mexico); Vaillant & Bocourt, Miss. Sci. Mex., 23, 1875, with pl. i, fig. 2; Jordan & Evermann, Bull. 47, U. S. Nat. Mus. 1121, 1896 (coast of Mexico and State of Oaxaca. Recorded by Steindachner from Bahia).

D. VIII–I, 10; A. III, 6; scales 11–67 to 69–15 to 17; head, measured to end of opercular flap, 2.6; depth 3.5 to 3.7; snout 3.4 to 4 in the head; eye 4.7 to 6.2 in head, 6 to .9 in interorbital; 2nd anal spine 1.4 to 1.7 in head; 3rd dorsal spine 2.1 to 2.2 in head.

This is a salt-water fish sometimes entering the streams for quite a distance. Taken in abundance and of large size off the eastern coast of Guatemala. My specimens were killed with dynamite in Machaca river, 13 miles from the coast 4 miles east of Tenedores. This means that these fishes had traveled at least 20 miles up stream. Largest specimen taken in fresh water is 41 cm. long.

HÆMULIDÆ.

Pomadasys *Lacépède.*

31. **Pomadasys templei** *Meek.*

Pomadasys templei Meek, Fresh-Water Fishes of Mexico, 201, 1904 (Valles and Perez).

D. XIII, 12 to 13; A. III, 7; scales 8 to 9–55 to 56–16; head 2.8 to 2.9 in body; depth 3.2 to 3.3 in body; eye 2.9 to 3 in head. .8 to 1 in interorbital; 2nd anal spine 1.5 in head; 4th dorsal spine 2.3 to 2.5 in head.

Three specimens, maximum length of those taken from fresh water 25.5 cm. This is an oceanic fish that ascends the rivers.

Localities: Sulphur River 3½ miles west of Puerto Barrios; Rio Machaca 13 miles west of Puerto Barrios.

SYMBRANCHIDÆ.

Symbranchus *Bloch.*

Geographical distribution: India, Tropical America, southern Mexico and St. Lucia south to the La Plata.

32. **Symbranchus marmoratus** *Bloch.*

Symbranchus marmoratus Bloch, Ichthyologia, IX, 87, pl. 418, 1795; Günther, Cat., VIII, 15, 1870; Jordan & Evermann, Fishes Middle and North America, Bull. 47, U. S. Nat. Mus. I, 342, 1898; Meek, Fresh-water Fishes of Mexico, 89, 1904.

Symbranchus immaculatus Bloch, *l. c.*, pl. 419, fig. 1.

Symbranchus transversalis Bloch & Schneider, 524, 1801 (Guiana, after Gronow).

Unibranchapertura grisea, marmorata, immaculata, and *lineata,* Lacépède, Hist. Nat. Poiss., V, 658, 1803 (Surinam).

Symbranchus fuliginosus Ranzani, Nov. Comm. Ac. Sci. Inst. Bonan., IV, 75, pl. ii, fig. 1, 1840 (Brazil).

Muræna lumbricus Gronow, Cat. Fishes, 18, 1854 (Sea of Guiana).

Symbranchus vittatus Castelnau, Anim. Amér. Sud, 84, pl. 44, fig. 3, 1855 (Rio de Janeiro).

Recorded from Vera Cruz, Trinidad, St. Lucia, Lake Peten, Huamuchal, Rio Chisoy.

My two specimens were taken from a pond at edge of Los Amates. Maximum length 11.3 cm.

56.7,58Z (729.7).

Article III.— *ZEBRASOMA DEANI*, A FOSSIL SURGEON-FISH FROM THE WEST INDIES.

By L. Hussakof.

Plate VII.

The following description is based on an exceptionally fine specimen of a fossil teuthid[1] from Antigua Island, West Indies, recently acquired by the American Museum (May 1905; Cat. No. 7483). The fossil was found in a quarry belonging to Mr. Oliver Nugent of that place. Its exact horizon is not known, but it was stated to be of Tertiary age and to have come from a level of about 200 feet above sea. Considering that the fossils of this family are most frequently found in Eocene formations, notably at Monte Bolca, and that rocks of similar age are extensively developed in the West Indies, it may well be that the fish in question is from an Eocene horizon.

There are two facts concerning this specimen which endow it with an unusual interest. (1), It is the first instance of a fossil of the family Teuthididæ found in America, all the hitherto recorded species, about a dozen in number, and representing four genera,[2] having come from Europe. And (2), it is the first fossil species known that is referable to the genus *Zebrasoma* Swainson.

Plate VII gives an excellent idea of the fish. It was evidently an adult individual, measuring 290 mm. in length. It is imbedded in a fine-grained buff-colored limestone. The substance of the fish is almost entirely gone having, perhaps, adhered to the counterpart; but nearly all the skeletal elements have left a clear imprint in the matrix which reproduces excellently all the skeletal characters. Unfortunately, in the abdominal region where the viscera were extruded in the post-mortem changes, the fish is injured, the ventrals as well as the anterior portion of the anal being lost. But despite the absence of these structures which would have helped in classification, it is apparent from the undoubted teuthid characters of the fish and from its small number of dorsal spines, that it belongs to the genus *Zebrasoma* of Swainson.

[1] The term Teuthididæ is employed throughout this note as synonymous with Acronuridæ (Günther) over which it has priority (*cf.* Dr. Gill in Proc. U. S. Nat. Mus., VII, 1884, p. 275.

[2] A. S. Woodward: Cat. Fos. Fishes Brit. Mus., Part IV, 1901, p. 562. C. R. Eastman: Bull. Mus. Compar. Zoöl., XLVI, 1904, pp. 1–35, *passim*.

It is worthy of note, in passing, that some features of the fish bring to mind the Balistidæ, *e. g.*, the abbreviation of the vertebral column — to 19 vertebræ (8+11) — the number in the Teuthididæ being typically 22 (9+13). Secondly, the first dorsal spine is notably strong and well developed suggesting an incipient 'trigger.' These characters, it seems to me, go to support the view of Jordan and Evermann that "There can be no doubt of the common origin of Balistidæ and Teuthididæ and that the divergence is comparatively recent." [1]

The species is named for my esteemed teacher in ichthyology, Professor Bashford Dean.

Genus **Zebrasoma** *Swainson.*

1839. *Zebrasoma* SWAINSON, Nat. Hist. and Class. Fi. etc., Vol. II, p. 256.
1861. *Acanthurus* (§ IV), GÜNTHER, Cat. Fi. Brit. Mus., Vol. III, p. 326.
1876. *Acanthurus* (D. *Harpurus*), DAY, Fi. of India, Vol. I, pp. 203, 207.
1884. *Zebrasoma* GILL, Proc. U. S. Nat. Mus., Vol. VII, p. 279.

Distinguished from *Teuthis* (*Acanthurus*) chiefly in having a reduced number (3 to 5) of dorsal spines. Living forms confined to the Indian and Pacific Oceans.

Zebrasoma deani sp. nov.

Head in total length, 4 times; depth, $2\frac{4}{5}$. Abdominal vertebræ 9; caudal 11. Dorsal fin, IV, 28; rather low, extending from immediately back of supraoccipital crest to over the ninth caudal vertebra; first spinous ray rather stout, 16 mm. high, which is about $\frac{3}{4}$ height of the articulated rays over middle of body; fourth dorsal spine as high as articulated rays following. Anal fin not completely preserved, only the posterior portion with about 16 rays present; 14th ray from posterior end has its interhæmal overlapping hæmal of 5th caudal vertebra. Caudal but little emarginate, with lobes subequal; its height equal to maximum depth of body; caudal pedicle very narrow, 9 mm. Caudal spines not preserved. Lateral line continuous. Profile of head inclined about 45 degrees to axis of body; very gently convex. Jaw and suspensorium, as in typical species of this family. Teeth setiform, dilated at extremities, crowded and probably movable; about 16 in one half of upper jaw, about 10 in half of lower. Body covered with minute shagreen-like scales.

Formation and *locality*: Tertiary, Antigua Island, West Indies.

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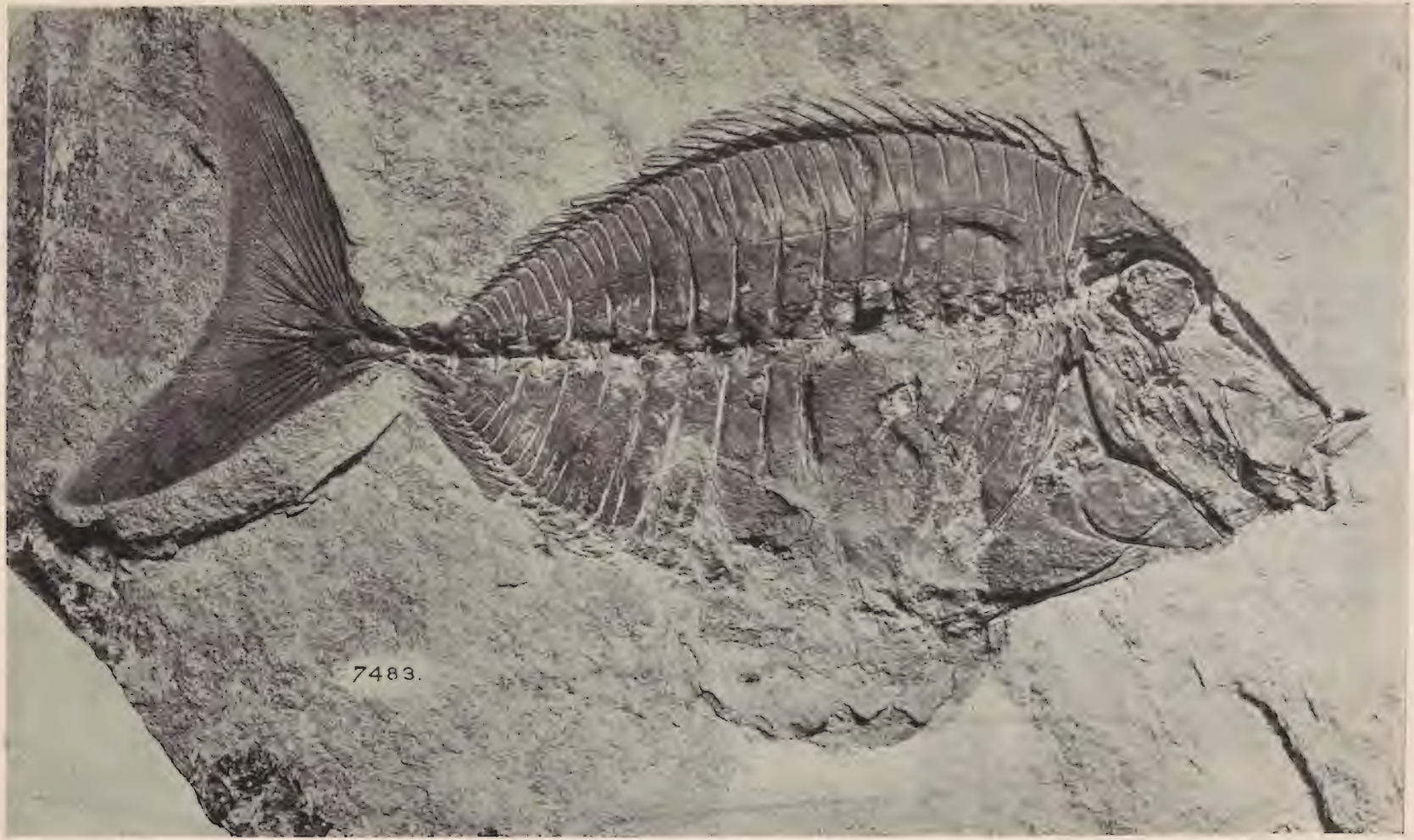
[1] The Fishes of North and Middle America. Bull. U. S. Nat. Mus., Vol. XLVII, Part iii, 1898, p. 1696.



Zebrasoma deani sp. nov. ×⅔.

Article IV.— AN ENUMERATION OF THE LOCALITIES IN THE FLORISSANT BASIN, FROM WHICH FOSSILS WERE OBTAINED IN 1906.

By T. D. A. Cockerell.

When the material collected at Florissant, Colo., by the expedition of 1906 is fully worked out, it will be possible to compare the faunæ and floræ of the several localities in detail. It was evident even in the field, that the various beds were not all strictly contemporaneous, but whether there is a great interval of time between any of them, and what is the proper succession of those in different localities, are questions the discussion of which is best deferred until the fossils have been determined. In the meanwhile, however, it is necessary to refer to the several localities and beds, and it will conduce to clearness and save repetition if these are enumerated in a short paper devoted to this purpose.

Station 1.— Shale with conchoidal fracture in a small gulley near the graveyard, estimated to be 150 feet above the level of the town. This is on the divide between the northern and southern portions of Lake Florissant.[1] The fossils from this locality are principally freshwater Mollusca; *Planorbis florissantensis, Sphærium florissantense, Limnæa scudderi* and *L. sieverti.* Some bones and teeth, apparently mammalian, were also found, but they have not yet been freed from the matrix and studied.

Station 2.— Gulley by Cripple Creek road, west of graveyard, where the shale just appears at one point near bed of gulley. No fossils found except wood fragments, which come out of the earth, not out of the shale. The earth above the shale is doubtless Pleistocene; some species of Elephantidæ (presumably *Elephas*) was found in it years ago, according to local report.

Station 3.— Exposure close to the house occupied by the party in Florissant. This is in a bluff on the north side of the town, next to the road leading to Lake George. It is reddish, and full of vegetable remains, not very well preserved. It includes a considerable quantity of charcoal. A few rather good fruits were obtained.

Station 4.— Fossil-Stump Hill, just above the large fossil stump— (Henderson, Univ. of Colo. Studies, 1906, fig. 3, opposite p. 151). The hill is capped by lava, below which is about 23 feet of laminated shale, the fossils coming from about one-third of the way down from the top of this. Below

[1] This name is used to designate the Tertiary lake in which the Florissant shales were deposited.

this thick bed is about ten feet of irregularly bedded non-fossiliferous shale, extending to the base of the fossil stump, and originally enclosing it. Other shale extends *below* the level of the fossil stump (*cf.* Station 15).

Station 4, in the laminated shale, yields *Myrica drymeja, Populus lesquereuxi, Planera longifolia, Lomatia acutiloba, L. terminalis,* etc.

Station 5.— Railroad cut east of Florissant station. This is the place

Fig. 1. Fossil Stump of Sequoia Tree near Florissant, Colorado.

where the "wild-flower excursion" trains stop, and tourists are allowed to get out and collect fossils. It is the type locality of *Salix ramaleyi, Quercus ramaleyi* and *Amelanchier scudderi.* Insects are exceedingly scarce with the exception of *Corixa florissantella,* which is abundant, and which has been found in no other locality. The *Planera,* so common in other places, appears to be absent, but *Myrica drymeja* occurs in layer G. An *Alnus* occurs, having the characters of *A. kefersteinii,* and an *Ulmus* is provisionally referred to *U. braunii. Carpinus fraterna* is common in layer J, where *Staphylea acuminata* also occurs, but rarely. A *Rhus* is referred to *R. subrhomboidalis.*

The following section was taken at 5, counting from the top down :

1. Layer G. Six inches of laminated gray shale, with many small dark fragments.
2. Layer H. Two feet of thick gray shale, with conchoidal fracture; many plants, but no insects.
3. About 8 feet of similar shale, but more laminated, and without distinct conchoidal fracture.
4. Layer J. About two feet of shale, containing *Corixa*.
5. About ten feet to level of railroad, covered by talus.

Station 6.— Tunnel in side of hill beyond Wilson's (on road to Lake George). This is a large tunnel sunk obliquely into the side of the hill, affording a very complete series of layers or beds, which were recorded as follows, counting from the top down:

1. Hill above mouth of tunnel, about 25 feet, mainly pale gray with reddish, not truly laminated.
2. Layer F. Some finely laminated shale.
3. About 8½ feet of yellow sand, with granitic particles.
4. Two feet; yellow laminated with some alternating gray conchoidal.
5. Two inches of conchoidal shale.
6. ¼ inch yellow laminated.
7. 1½ inch conchoidal.
8. 1 inch yellow laminated.
9. 3 inches conchoidal.
10. Layer E. 5½ inches yellow laminated, fossiliferous.
11. 8½ inches conchoidal, reddish. One insect found.
12. Layer D. 4½ inches yellowish laminated, fossiliferous (specimens marked S D are from about three feet below D.)
13. 3½ inches gray conchoidal.
14. 1½ inches yellowish laminated.
15. 6 inches heavy conchoidal.
16. ½ inch yellowish finely laminated.
17. 3 inches gray conchoidal.
18. ½ inch closely laminated.
19. 3 inches gray conchoidal.
20. 2½ inches yellowish closely laminated.
21. 8 inches gray with conchoidal fracture.
22. One foot closely bedded yellowish gray with layers of crystals.
23. Three feet massive gray with conchoidal fracture.
24. Layer C. One foot gray and black streaked, fossiliferous.
25. One foot gray.
26. Three inches sulphur-color and gray.
27. Layer B. One foot gray and black, fossiliferous (*Planera*, etc.).
28. One foot, sulphur-color and black.
29. Four inches laminated dark gray, granular.
30. 2½ inches sulphur and black.
31. 3 inches massive gray.
32. 2 inches sulphur and black.

33. 8 inches massive gray.
34. 16 inches soft shale, light yellow with black layers.
35. 5 inches soft gray shale.
36. Layer A. One foot, black and white layers, with leaves of *Planera*, etc.
37. Nine feet of massive gray shale, to bottom of tunnel.

It will be noticed how the conchoidal layers alternate with the laminated. It is to be inferred that the former represent flows or showers of volcanic ash, and the latter the effect of water in working over the surface of such deposits. The indications would be that in this locality there were many

Fig. 2. Ancient Miocene Lake-Bed at Florissant, Colorado, looking north from Station 4.

slight eruptions, or if the eruptions were severe, they were not close at hand. The local severity of each fall, and the period intervening between each two, may perhaps be roughly estimated from the thickness of the layers.

Station 7.— By the road, just before reaching Wilson's ranch; bluff facing south. Probably the equivalent layer D in Station 6. Leaves and insects were found.

Station 7a.— Miscellaneous small outcrops near Wilson's.

Station 8.— Lava on hill just opposite Station 5. Contains remains of wood.

Station 9.— Side of hill facing north, about a mile southwest of the town, in the direction of, but beyond, the Y on which the locomotives turn. K is the top layer; L is halfway down. At the base of this hill is a swamp, and the opposite bluff is granitic.

Station 9, or some place immediately adjacent, is the type locality of *Malvastrum exhumatum* and *Myrica hendersoni*. *Planera longifolia* occurs in layer L.

Station 10.— Bed of thick laminated shale close to east end of Lake George. Contains a few poorly preserved leaves and twigs, and great quantities of an undescribed ostracod. This is the most western locality for the Florissant shales yet found, and is nearly two miles beyond Scudder's limit, as indicated by his map.

Station 11.— North end of Fossil Stump Hill. This is the locality of Scudder's section given in his 'Tertiary Insects,' pp. 21, 22. It furnished us with *Tmesipteris alleni, Comptonia insignis, Myrica drymeja, Populus lesquereuxi, Planera longifolia, Lomatia acutiloba, L. terminalis, Celastrus fraxinifolius, Acer mysticum, Sterculia rigida,* and many other plants. Among insects obtained there, perhaps the finest was *Tipula rigens*. The spider *Tetragnatha tertiaria* was also found.[1]

Station 12.— West side of Fossil Stump Hill. Plants and insects found.

Station 13.— Shale on hill sloping south, opposite 9 and 14. It consists of alternating flows of sandy lava, forming sandstone layers, and fine laminated shale. The whole appears to dip *under* 9, but there is probably a fault.

The hill containing 9 and 14 is capped with coarse granite gravel, showing long exposure. The opposite hill, looking over 13 and against 9 (with the marsh between it and 9), consists of massive granite rock, with many detached boulders; there is a layer of shale on the top.

Station 13 furnished many plants and insects; among the latter a perfect specimen of *Hodotermes coloradensis*, and a very good *Palæovespa scudderi*. The plants include *Sphenopteris guyottii, Typha lesquereuxi, Myrica drymeja, Planera longifolia,* etc.

Station 14.— On same hill as 9, at level of L, but a little further west. This locality was extensively worked, and furnished our best materials. The fossil-bearing layer is capped by a very thick layer of massive rock, which doubtless conduced to the excellent preservation of the specimens. On a single slab at this locality we found *Populus lesquereuxi, Typha lesquereuxi, Cotinus fraterna,* and *Planera longifolia,* proving their exact contemporaneity and also contiguity. Another slab contained *Myrica drymeja*

[1] *Tetragnatha* is represented in the modern fauna of Florissant by *T. laboriosa* Hentz, kindly determined for me by Mr. N. Banks.

and *Populus lesquereuxi.* The leaves of the *Populus* grew to a great size; one was 70 mm. broad.

Station 15.— At Fossil Stump Hill; a lignitic layer one or two feet *below* level of the fossil stump. Contained remains of fern, sequoia (apparently) and the snail *Planorbis.* The exact place is about 8 yards northeast of the stump. The fern looked like an Eocene species.

Station 16.— In gully southeast of town, behind railroad-cutting hill. Here we obtained fish-scales.

Pleistocene (see also under Station 2).

The north fork of Twin Creek has extensive peaty layers of mostly charred remains. No shells were found, though considerable search was made. The beds have a bluish-gray color, with coarse gravel in layers between. The following section describes the beds as found in one place on the west side of the creek, from above down:

1. Recent alluvial earth and gravel, 13 inches.
2. Blue-gray soil, 9 inches.
3. Coarse gravel, 8 inches.
4. Blue-gray, with vegetable fragments, 2 feet.
5. Coarse gravel, 1 foot.
6. Blue-gray with gravel intermixed; contains charcoal, 6 inches.
7. Gravelly alluvium, 2 feet.

The members of the expedition were Dr. W. M. Wheeler, Mr. S. A. Rohwer, and Mr. and Mrs. Cockerell. In addition, Miss Josephine Cowie and Miss Neva Lillie spent ten days with us in June and collected a number of fossils. Visitors, who did some collecting, were Miss J. Bentley and Miss B. Hopkins.

56. 57. 33 (78.8)

Article V.— FOSSIL DRAGONFLIES FROM FLORISSANT, COLORADO.

By T. D. A. Cockerell.

Lithæschna gen. nov. (Æschnidæ.)

Type *L. needhami*, sp. nov. (Fig. 1.) Florissant, Station 14 (W. P. Cockerell, July 7, 1906). A genus of apparently primitive Æschnidæ, partaking of the characters of the Gomphinæ and that group of Æschninæ in

Fig. 1. *Lithæschna needhami* sp. nov. About twice natural size. Veins inked in photograph.

which the radial sector is unbranched. I am greatly indebted to Dr. J. G. Needham for placing in my hands a number of his unpublished figures and notes, and for helpful suggestions, all of which have enabled me to determine the relationships of the fossil far more exactly than would otherwise have been possible.

The following table shows how *Lithæschna* may be separated from a number of genera of Æschnines in which the radial sector is unbranched. It is based exclusively on the hind wings.

Oblique vein separated from origin of M_2 by several cells [1] . . . . . 1.
Oblique vein separated from origin of M_2, if at all, by not more than a cell and a half . . . . . 2.

[1] This is also a character of *Phyllopetalia* (Chilian region), and in a less degree of *Cordulegaster* and *Chlorogomphus*.

1. M_2 strongly bent, separated at the bend from Rs by 3 or 4 rows of cells; triangle with few cells (Solenhofen, Bavaria; Jurassic) . . . . . *Morbœschna.*[1]
   M_2 moderately bent, not thus separated from Rs; triangle with many cells (Jurassic; Bavaria) . . . . . *Cymatophlebia.*
2. Stigma elongated, its lower margin bounding $4\frac{1}{2}$ cells; anal loop rather large, with 7 or 8 cells . . . . . 3.
   Stigma shorter, bounding less than 3 cells below . . . . . 4.
3. Anal region more developed with 4 rows of cells between the anal loop and the inner margin: basal space reticulate . . . . . *Boyeria irene,* Fonsc.
   Anal region less developed, with 3 rows of cells between the anal loop and the inner margin: basal space free from crossveins . *Basiæschna janata* Say.
4. Anal loop large, with 10 cells . . . . . *Hoplonæschna armata* Hagen.
   Anal loop with not over 5 cells . . . . . 5.
5. Opposite the brace, M_2 nearer to M_1 than to Rs . . . . . 6.
   Opposite the brace, M_2 nearer to Rs than to M_1 . . . . . 7.
6. Anal loop of 3 cells; triangle of 3 cells; oblique vein separated from origin of M_2 by $1\frac{1}{2}$ cells (Borneo) . . . . . *Dolœschna.*
   Anal loop of 4 cells; triangle of 2 cells; oblique vein separated from origin of M_2 by one cell . . . . . *Gomphœschna furcillata* Say.
7. Anal loop of 5 cells; triangle of 3 cells; oblique vein arising at origin of M_2 *Lithœschna needhami* Ckll. (n. g., n. sp.).

Although the radial sector (Rs) in these forms is unbranched, there is an oblique cross-vein below Rs, which seems to indicate the beginning of a branch, especially in *Boyeria.* This oblique vein is below the sixth cell from origin of M_2, and fifth from the oblique vein properly so-called in *Gomphœschna*; below the sixth cell from origin of M_2 and seventh from the oblique vein in *Boyeria*; below the seventh cell from origin of M_2 and second from the oblique vein in *Morbœschna*; below the seventh and fifth from the oblique in *Dolœschna*; below the seventh and sixth from the oblique in *Basiæschna.* In his diagrams, Dr. Needham designates the oblique vein proper by O; the oblique vein below the Rs may be called O_2. I cannot distinctly determine the existence of O_2 in *Lithœschna.*

In order to further elucidate the characters of *Lithœschna needhami,* it is necessary to discuss them one by one, in comparison with the allied genera.

Anal angle.

Little developed in *Lithœschna,* thus approaching *Basiæschna* and differing from *Boyeria.*

Rows of cells between first part of Cu_2 and lower margin of wing.

Three in *Gomphœschna.*
Four in *Basiæschna* and *Lithœschna.*
Four to five in *Boyeria.*
Six in *Cymatophlebia.*
Six to seven in *Morbœschna.*

[1] Described by Dr. Needham on p. 141, *post.*

Triangle.

In *Lithæschna* practically as in *Basiæschna*, with two cross-nervures.
It is not so elongated as in *Boyeria*.

Anal loop.

With 3 cells in *Dolæschna*, as also in *Gomphoides stigmatus* Say.
With 4 cells in *Morbæschna*, as also in *Gomphæschna*.
With 5 cells in *Lithæschna*.
With 6 cells in *Æschna polydore* Heer (fossil at Œningen), and, as Dr. Needham remarks, shaped much as in *Lithæschna*.
With 7 cells in *Basiæschna*, and not very different from *Lithæschna* in form.
With 8 cells in *Boyeria*.

Cubitus (Cu_1 and Cu_2).

In *Lithæschna* Cu_2 is moderately bent at base, much as in *Gomphus*,— not so strongly bent as in *Gomphæschna*. It then runs parallel with Cu_1, for at least 7 cells, when it branches, enclosing 5 or 6 cells, the upper branch being arched, and so approaching nearer to Cu_1. This is not unlike *Morbæschna*, *Boyeria*, *Basiæschna* and *Gomphæschna*, but differs entirely from *Gomphus*.

Antenodal sectors.

Eight in *Gomphæschna*.
Eleven in *Lithæschna*, or possibly 12.
Twelve in *Hoplonæschna*.
Thirteen in *Basiæschna*.
Fifteen in *Boyeria*.

Oblique vein.

1. Arising at same point as origin of M_2 from M_1 . . . . . *Lithæschna*.
2. Forming the apical margin of cell from about the middle of which M_2 arises from M_1 . . . . . *Hoplonæschna*.
3. Forming the apical margin of the cell, the base of which is even, or nearly even, with the origin of M_2 from M_1 . . *Boyeria*, *Gomphæschna*, and *Basiæschna*.
4. Arising several cells beyond the origin of M_2 from M_1 . . . *Morbæschna*.

Stigma.

Stigma not especially slender.
Bounding $1\frac{1}{2}$ cells below . . . . . *Gomphæschna*.
Bounding $2\frac{1}{2}$ cells below . . *Lithæschna*, *Hoplonæschna* and *Morbæschna*.
Stigma slender, bounding $4\frac{1}{2}$ cells below . . . . . *Basiæschna* and *Boyeria*.

In *Lithæschna* the stigma is slightly swollen, rather over $2\frac{1}{2}$ times as long as broad, and is much like that of *Morbæschna*, except that it is longer in the latter. The brace is essentially the same in all these genera.

Radial sector.

Strictly unbranched in *Lithæschna*; it is separated from M_2 by a single row of cells, except at the place where they are widest apart (at bend of M_2). where there are 3 or 4 double cells. In *Gomphæschna* the double cells begin at about the same point, but continue to margin.

M_2 and Radial sector.

At the point of greatest distance between M_2 and Rs, there are —

a. Two rows of cells between: *Lithæschna* and *Gomphæschna.*

b. Three rows of cells between: *Basiæschna, Boyeria* and *Hoplonæschna.*

c. Four rows of cells between: *Morbæschna.*

The number or single-row or simple cells beyond the oblique vein, before the doubling begins, is —

Four in *Morbæschna.*
Seven in *Gomphæschna.*
Eight in *Lithæschna.*
Nine in *Hoplonæschna.*
Eleven in *Boyeria* and *Basiæschna.*

M_2.

1. Gently curved, a little nearer to Rs than to M_1, opposite brace (a Gomphine character) . . . . . *Lithæschna.*
2. Gently curved, about equally distant from Rs and M_1, opposite brace. *Gomphæschna.*
3. More abruptly curved, and nearer to M_1 . . . *Boyeria* and *Hoplonæschna.*
4. Still more abruptly curved or bent, and much nearer to M_1 . . *Morbæschna.*

Gomphæschna has three rows of cells between M_1 and M_2 in apical field of wing, except on extreme margin, where there are five. *Lithæschna* has four rows, but an extra row of two cells only at apical margin.

Basiæschna has five rows, but six on extreme margin. *Boyeria* has seven rows but nine on extreme margin. *Hoplonæschna* has about seven on extreme margin, but fewer in submarginal area, though at least five.

M_3 and M_4.

1. Distal part of M_3 and M_4 strongly undulate . . . . . *Morbæschna.*
2. Distal part of M_3 and M_4 slightly undulate . . . . . *Gomphæschna.*
3. Distal part of M_3 and M_4 not or hardly undulate *Lithæschna, Boyeria* and *Basiæschna.*

In *Lithæschna* M_3 and M_4 are separated by only a single row of cells, at least to near margin (actual margin at this point obliterated); this agrees with *Gomphæschna,* and differs from *Boyeria,* etc.

It appears from all the above, that as long as we confine our attention to the basal field of the wing of *Lithæschna,* we find much resemblance to *Basiæschna*; but in the apical field this disappears, and the resemblance is rather to *Gomphæschna,* while certain characters are decidedly Gomphine. We are at liberty to infer, perhaps, that the apical field in *Basiæschna* has undergone change, while the basal field has remained comparatively stationary.

Lithæschna needhami is represented by a single hind wing, about 33 mm. long. The species is appropriately dedicated to the author whose writings and investigations have made this study possible. The wing is hyaline, without markings.

Lithagrion *Scudder.* (Agrionidæ.)

Lithagrion hyalinum *Scudder.*

(Fig. 2).

At Station 14 a good specimen was found, with its reverse. The stigma has a brace vein (this fact is not apparent from Scudder's figure), the quadrangle is not divided by any cross-veins, and vein M_3 arises nearer nodus than arculus. Scudder's specimen did not show the whole of the stigma; it is perfect in ours, 3 mm. long, bounding $3\frac{3}{4}$ cells below. Its inner corner is not produced and pointed, as it is in *Heteragrion* and *Amphi-*

Fig. 2. *Lithagrion hyalinum* Scudder. $2\frac{1}{2}$ times natural size. Veins inked in photograph.

pteryx. In *Epallage* the stigma also bounds between three and four cells, but it is very long, and one of the bounding cells is very long, while there is no brace-vein. In *Archilestes* there is a brace, and the stigma with its subtending cells is very much like that of *Lithagrion.* The stigma of the fossil also recalls that of *Ortholestes,* but in that genus there is no distinct brace, or at least the oblique vein serving that purpose arises beyond the basal corner of the stigma. Scudder figures only one antenodal cross-vein in *Lithagrion hyalinum.* In our example, the antenodals are mainly obliterated, but I feel quite confident that there are at least three. This is, no doubt, a primitive character, and the whole appearance suggests very strongly the Calopterygine genus *Micromerus.*

The subquadrangle of *Lithagrion hyalinum* is strongly bent at the arculus, and veins M_{1-3} and M_4 arise from the upper part of the arculus, — more

so than Scudder's figure shows, both being well above the middle of the arculus.

Lithagrion umbratum Scudder, with its smoky wings, the stigma bounding five cells below, and the cells of the first two rows between nodus and stigma higher than long, appears to represent a distinct genus, which may be called Melanagrion, gen. nov.

Melanagrion umbratum also has this peculiarity, that the arculus is bent, and M_4 arises from it at the bend, which is *below* the middle, and away from the origin of M_{1-3}. This is an arrangement like that found in *Epallage*; whereas *Lithagrion hyalinum* has the arculus and arising M veins almost as in *Ortholestes*. The quadrangle of *Lithagrion hyalinum* is somewhat longer, especially on the upper side, than Scudder's figure would suggest.

Hesperagrion prævolans sp. nov.

(Fig. 3.)

Station 14.— Type in Amer. Mus. Nat. Hist.; reverse at University of

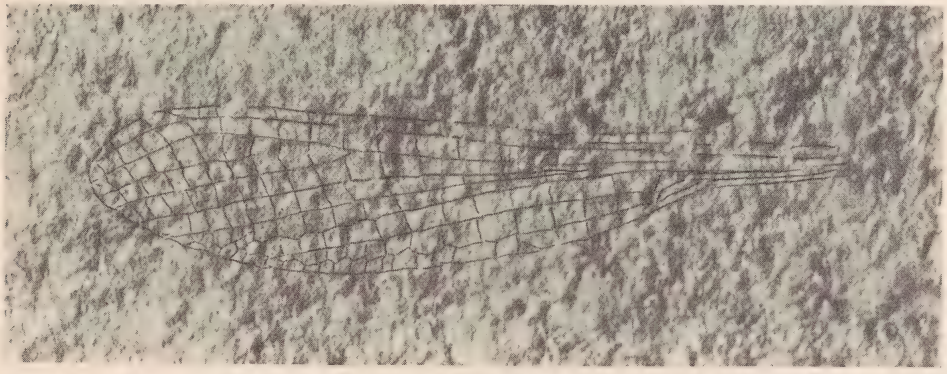


Fig. 3. *Hesperagrion prævolans* sp. nov. 3¾ times natural size. Veins inked in photograph.

Colorado. Represented by a single perfectly hyaline wing, 21⅓ mm. long. Veins brown: stigma hyaline with a dark margin.

The venation agrees with that of *H. heterodoxum* Selys, as figured by Needham (Proc. U. S. Natl. Mus., XXVI, pl. liv, f. 5), except in the following slight particulars —

1. The stigma is more oblique, and longer in a diagonal direction, so that it is truly lanceolate.
2. The costal cell following the stigma is much longer than high.
3. The oblique apical side of the quadrangle is not noticeably shorter than the upper side.
4. The antenodal portion of the costa is visibly arched.

5. The cells between the nodus and the stigma, on costal margin, number eleven.

I was at first inclined to refer the wing to *Agrion exsularis* Scudd., but it differs as follows: —

1. The stigma is differently shaped, being more produced diagonally.

2. The upper side of the quadrangle is much longer; the quadrangle (as also the stigma) of *exsularis* is like that of *Enallagma.*

3. There are only three simple cells between M_1 and M_2 before the doubling begins; in *A. exsularis* there are four.

Trichocnemis aliena Scudd. agrees better with *H. prævolans* in regard to the quadrangle, but the other characters are as in *A. exsularis.* The subquadrangle is represented as having a cross-vein, which certainly is not present in *H. prævolans.* If *T. aliena* and *A. exsularis* had not been described by the same author, I should suspect their identity.

Hesperagrion is a genus still extant in our southwest.

56.57,33A(78.8)

Article VI.— SUPPLEMENTAL DESCRIPTIONS OF TWO NEW GENERA OF ÆSCHNINÆ.

By James G. Needham.

When Professor Cockerell was collecting fossils at Florissant he wrote me of the discovery of the *Lithæschna* described in the foregoing pages, and sent me a sketch of its venation. Having in my possession some unpublished figures of related genera, I sent them to him for whatever use he

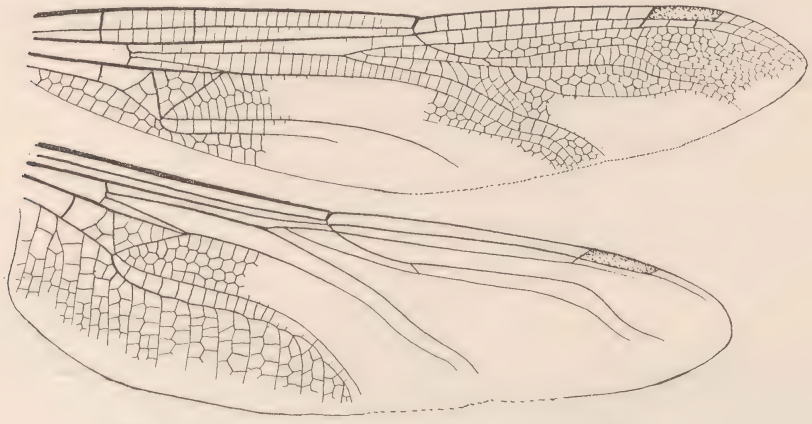


Fig. 1. Venation of *Cymatophlebia longiolata* Muenst.

might choose to make of them. These included a drawing of the venation of *Cymatophlebia* (probably the type species *C. longiolata* Muenst.) more complete than any that have been published, a drawing of the venation of another fossil Æschnine, and a photograph of a recent undescribed genus from Borneo. The specimens are in the Museum of Comparative Zoölogy at Cambridge, where in 1897, through the kindness of Mr. Samuel Henshaw and Dr. R. T. Jackson, I had the privilege of studying them and of making these figures. The two last mentioned represent genera as yet undescribed.

Professor Cockerell has made good use of the figures in the comparisons of the foregoing paper, and has invited me to add descriptions of the two new genera. Since it is desirable under the circumstances that these should be made known, I append brief diagnoses of them, with figures, inserting my new figure of *Cymatophlebia* (Fig. 1).

Morbæschna gen. nov.

Type, the specimen labelled *Æschna muensteri* Germar in the Hagen collection of fossil Odonata in the Museum of Comparative Zoölogy.

Only the venation of this specimen is in a sufficiently good state of preservation to admit of critical diagnosis. Its chief characters are shown in Fig. 2, and are as follows: —

Stigma with a strongly developed brace vein; ante- and post-nodals in the fore wing about 12 and 10, in the hind wing about 10 and 12 respectively; arculus slightly arcuated, especially in the fore wing, the sectors arising from it well separated and with gentle curvature; proximal end of the bridge slightly more identified vein

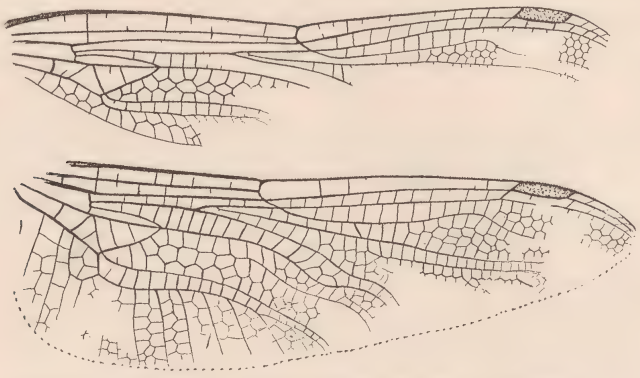


Fig. 2. Venation of *Morbœschna muensteri* (Germar).

M_{1+2} then with vein M_3; oblique crossvein 4 to 5 cells beyond the subnodus: veins M_1 and M_2 separated by a single row of cells as far as the brace vein of the stigma (at which point they are most approximated), then diverging, with three rows between; a straightened line of crossveins one row of cells behind the radial sector, simulates a radial supplement; veins M_3 and M_4 are sinuated in their middle course, the space between them is widened at the sinuation and narrowed again beyond in the hind wing: no crossveins are discoverable in the super-triangle; there are two in each triangle and there are at least three cubito-anal crossveins; there are three rows of post-triangular cells, and in the hind wing there is a sinuous median supplement paralleling vein M_4 and separated from it, first by one, then by two, then by one, and finally by three rows of cells; the branches of the cubital vein in the hind wing are separated by a single row of cells, and are approximated beyond the level of the triangle, vein Cu_2 having about seven distinct straight posterior branches extending to the hind margin; the compact anal loop consists of four cells, and behind it are at least two straight sectors extending from the cubital vein to the hind margin.

Dolæschna gen. nov.

Type, *D. elacatura* sp. nov.

Most nearly allied to *Gomphæschna*. The venational characteristics of the genus are as follows: The stigma has a strong brace vein, and two additional crossveins meet its hind margin; ante- and post-nodal crossveins are in the fore wing 17 and 8 or 9, and in the hind wing 12 and 9 respectively; the first two branches of the median vein are most approximated at the level of the stigma, after which they diverge to include two rows of cells to the margin; between the hinder of these and

the radial sector there are but two rows of cells from the upward bend to the wing margin; the oblique vein is but little more than one cell distant beyond the subnodus; the last two branches of the median vein are sinuate beyond their middle, and include for a distance two rows of cells between them; a more or less distinct median supplement parallels the hinder of these, separated from it by a single row of cells; there are but four principal branches arising from the vein Cu_2. The arculus is somewhat angulate at the approximated origin of its sectors; there are two crossveins in super triangle and in triangle in all wings, and there are two cubito-anal crossveins; there is a small anal loop, consisting of three cells, and there are no strongly developed sectors in the anal angle behind it.

A very remarkable, primitive Æschnine genus, with hemispherical head, eyes touching on the dorsal side for a little way, ovipositor arcuate and with the abdomen curiously spindle-shaped beyond the constricted third segment.

Dolæschna elacatura sp. nov.

Fig. 3.

Length 54 mm.; abdomen 42 mm.; hind wing 44 mm.

A brown species, apparently without thoracic stripes. Eyes contiguous

Fig. 3. *Dolæschna elacatura* sp. nov.

for a distance somewhat exceeding the breadth of the vertical tubercle. Frons obtusely projecting, unmarked above, with an obscure transverse ridge across its superior margin. Face receding to the mouth; labrum yellowish with brown border. Occiput naked, very narrow, and deeply notched behind between the eyes: face and vertical tubercle pubescent

with blackish hairs. Legs moderately short and slender, reddish, darker on the knees and tarsi; claws with a very minute tooth under the middle. Wings transparent amber brown, hyaline at apex and behind triangles; stigma reddish brown.

Abdomen constricted on segment 3, spindle-shaped beyond (whence the specific name), being depressed on segments 4–6 and strongly compressed on segments 7–9; brown, with pale (bluish?) half rings bordering the middle transverse carina behind on segments 2–9, interrupted on the mid-dorsal longitudinal carina, and narrowed laterally to form paired lance-triangular spots on segments 4–7; segments 8 and 9 paler below. Segment 3, about as long as 1 and 2 together and slightly longer than segment 4. Segments 4–6 are of equal length, and segments 7, 8 and 9 are successively a little shorter, with segment 10 hardly half as long as segment 9, and of very peculiar form. It is abbreviated dorsally and declined at hind margin. It is prolonged ventrally from its hind margin, and the prolongation is concave ventrally at base to receive the upcurving tips of the ovipositor blades; it is concave above at the tip, for the reception of the decurrent subanal lobes; the latter are clothed with re-curved hairs, and the hind border of the prolongation of segment 10 is beset with minute denticles. The palps of the ovipositor guides are about as long as the 10th segment and each is tipped with a pencil of brown hairs of equal length; the appendages are broken off.

Type, a single female from Mindai, Borneo, in the Museum of Comparative Zoölogy of Harvard College.

59.57,85c(7)

Article VII.— NOTES ON AND DESCRIPTIONS OF NEW FORMS OF CATOCALA.

By William Beutenmüller.

The notes on species of *Catocala* presented in this paper are the results of some of my studies on the species of that genus, and are published here in advance of my forthcoming monograph on the genus *Catocala* of America, north of Mexico.

Catocala jair *Strecker.*

Catocala jair Strecker, Ent. News. Vol. VIII, 1897, p. 116.

Two beautiful examples of *Catocala jair* from the Indian River district of Florida, are in the collection of Mr. Jacob Doll. In these specimens the basal area of the fore wings is dark smoky brown black and the median space brown, covered with blue gray scales. The reniform is indistinct, and the subreniform is round, whitish and ringed with black. From about the middle of the costa, is a black shade running obliquely to the middle of the transverse posterior line, where it is more pronounced.

The space between the transverse posterior and subterminal lines is brown. The terminal space is brown, rather densely covered with blue white scales with a brown black dash from below the apex to opposite the prominent angle of the transverse posterior line. The basal line is short and black. The transverse anterior line is black, very slightly dentate and oblique. The posterior transverse line is very much less dentated than in *Catocala amica*, with the teeth opposite the reniform very short and rounded; the rest of the line is slightly wavy. The terminal line is black and slightly dentate. The hind wings are similar in color to those of *Catocala amica*, with the fringes brown, white at the apex, while in *amica* they are brown tipped or cut with whitish.

This species is closely related to *C. amica*, but differs by having the fore wings broader, more pointed at the apex, and the transverse lines less dentate.

Catocala amica *Hübner.*

Ephesia amica Hübner, Zutr. Exot. Schmett., 1818, p. 14, fig. 57 (upper side) and 58 (under side).

Catocala lineella Grote, Trans. Am. Ent. Soc., Vol. IV, 1872, p. 18.

Hübner's figure of *Catocala amica* is the gray form with distinct dark transverse lines and without the black shade from the costa to the reni-

form and thence to below the apex on the outer margin on the fore wings. The anal black spot on the hind wings above is very minute, and the black spot in the yellow field on the hind wings beneath is wanting. The type locality is Florida.

An example of *C. amica* in the collection of the American Museum of Natural History agrees very well with Hübner's figure, and it is the same as Grote's variety *lineella*. Butler also states (Entomologist, Vol. XXV, 1892, p. 214) that he is unable to separate *Allotria* (=*Catocala*) *lineella* Grote from *C. amica Hübner*.

Catocala amica var. **androphila** *Guen.*

Catocala androphila Guenée, Hist. Nat. Spec. Gen. Lepid., Tom VII, Noct. III, 1852, p. 84; Grote, Trans. Am. Ent. Soc., Vol. IV, 1872, p. 18.

The description of *Catocala androphila* by Guenée applies to the form of *Catocala amica* in which the fore wings are pale gray with the lines fine and not very evident. A more or less distinct black median shade on the costa above the reniform is continued beneath it, running upward to the external margin below the apex.

Catocala cordelia *Hy. Edw.*

Noctua amasia Abbott & Smith, Nat. Hist. Lepid. Ga., Vol. II, 1797, p. 179, pl. 90 (upper figure).

Catocala cordelia Hy. Edwards, Bull. Brooklyn, Ent. Soc., Vol. III, 1880, p. 59.

The figure of *Catocala amasia* in the copy of Abbott and Smith in the American Museum of Natural History, agrees in color and markings with the species described as *Catocala cordelia* by Hy. Edwards. The name *amasia* of Abbott and Smith is preoccupied for a European species described by Esper (Schmett. Europa, Tom. IV, 1786, pl. cxciv, figs. 1, 2) and therefore *cordelia* should be used instead. Professor French's figure 1, (Can. Ent., Vol. XXXIV, p. 97) is *Catocala sancta* Hulst and not *C. amasia* A. & S.; and his figure 2 is *C. cordelia*; and figure 3 is what I consider to be *C. amasia* (=*cordelia*).

Catocala whitneyi *Dodge.*

Catocala whitneyi Dodge, Can. Ent., Vol. VI, 1874, p. 125; *ibid.*, Vol. XXXVI, 1904, p. 116; Grote, Bull. Buff. Soc. Nat. Sci., Vol. II, 1875, p. 222; Can. Ent., Vol. IX, 1877, p. 169; Papilio, Vol. I, 1881, p. 163; French, Synop. Catocala Illinois, 1881, p. 9; Can. Ent., Vol. XXXIV, 1902, pp. 34 and 96; Angus, Papilio, Vol. IV, 1884, p. 37; Snow, Trans. Kansas Acad. Sci., Vol. VII, 1881, p. 104; G. M. & E. A. Dodge, Can. Ent., Vol. XXXVI, 1904, p. 116.

Catocala nuptialis var. *whitneyi*, Check List Lepid. Brooklyn Ent. Soc. 1882, p. 19.

Catocala abbreviatella var. *whitneyi* Hulst, Bull. Brooklyn Ent. Soc., Vol. VII, 1884, p. 39.

I fully agree with Messrs. Dodge, Grote, French, and Angus in considering *Catocala whitneyi* a valid species and not a variety of *C. nuptialis* Walker, or *C. abbreviatella* Grote, as placed by certain writers.

The types of *whitneyi* were unfortunately destroyed by fire, as I am informed by Mr. Dodge, and the specimen in the Grote Collection in the British Museum, supposed to be the type is not one of the specimens from which the description was made. The species, however, is well known and easily recognized from the good description published by Mr. Dodge. There are two forms of *C. whitneyi*, one with light grayish, and the other with dark blackish, fore wings. Messrs. G. M. and E. A. Dodge who have taken *whitneyi* in numbers inform me that it is not found on tree trunks, like many species of *Catocalæ*, but is to be found in open fields, particularly around haystacks.

Catocala allusa *Hulst.*

Catocala allusa Hulst, Bull. Brooklyn Ent. Soc., Vol. VII, 1884, p. 45.
Catocala frenchii Poling, Can. Ent., Vol. XXXIII, 1901, p. 125.

The type of *C. allusa* Hulst is a female in the E. L. Graef collection, Brooklyn Institute of Arts and Sciences, and it is identical with *C. frenchii* Poling, there being no differences in color and markings whatever. A male example of *allusa* is also in the collection of Mr. Jacob Doll, which is somewhat darker in the color of the fore wings than the type form.

Habitat: Washington (Graef Coll.); New Westminster, B. C. (Poling Coll.), and Colorado (Doll Coll.).

Catocala ultronia *Hübner.*

Eunetis ultronia Hübner, Zuträge Exot. Schmett., 1823, p. 26, fig. 347 (upper side) and fig. 348 (under side).
Catocala ultronia var. *mopsa* Hy. Edwards, Bull. Brooklyn Ent. Soc., Vol. III, 1880, p. 58.

The form of *Catocala ultronia* figured by Hübner has the fore wings rich brown, with a darker shade from the base to near the middle, and one beyond the reniform to the margin of the wings. It is the same as the variety *mopsa* Hy. Edwards. The type locality of *ultronia* is Pennsylvania.

Catocala violenta *Hy. Edw.*

Catocala violenta Hy. Edwards, Bull. Brooklyn Ent. Soc., Vol. III, 1880, p. 58.
Catocala chiricahua Poling, Can. Ent., Vol. XXXIII, 1901, p. 127.

In the Bulletin of the American Museum of Natural History, Volume XIX, 1903, p. 507, I stated that *C. chiricahua* looked suspiciously like the female *C. violenta* and that it was probably the same. Mr. Doll informs me that he is also of this opinion, and his specimens which he considers

the females of *C. violenta* agree with *C. chiricahua.* According to Dr. Henry Skinner, *C. violenta* flies early in the evening among the tree tops making it very difficult to capture with the net.

Catocala eldoradensis *Beuten.*

The species described as *Catocala mariana* Hy. Edwards, MSS. by Strecker, in his Lepidoptera Rhopalocera and Heterocera, 1874, p. 99, is synonymous with *Catocala californica* and the species described subsequently as *Catocala mariana* by Hy. Edwards in his Pacific Coast Lepidoptera, no. 14, 1875, p. 33, is an entirely different looking insect. The name *mariana* cannot be employed for the latter and a new name is required. I propose for it *Catocala eldoradensis.* The name *C. mariana* also comes in conflict with the European *Catocala mariana* Rambur (Cat. Syst. And. 1858, taf. ix, fig. 4).

Catocala pura *Hulst.*

Larva: Head rather small, 3½ mm. high, and of equal width; slightly bilobed, flattened in front, with a polished setaceous tubercle on each lobe a little below the apex; color whitish, with reddish brown reticulated lines, those on the face not reaching the mouth parts at the sides and the frontal triangular piece; on each side is an irregular, narrow, black line, disconnected at the summit and running downward to the upper ocelli. The triangular frontal piece is white and narrowly margined with black. Ocelli black. Antennæ and palpi white. Mandibles white margined with black. Body whitish, sprinkled with numerous brownish dots, not contrasting; piliferous spots whitish, not conspicuous and prominent; eighth segment with a transverse fold-like ridge, on and behind which the dots are somewhat more numerous; eleventh segment somewhat elevated. Lateral fringes white. Underside white with a small reddish patch between each pair of thoracic feet, and a large red brown patch on each of the remaining segments, except the last. Thoracic feet white. Abdominal legs white with a few brownish dots; last pair with a short, elongated black mark at the middle, anteriorly. Anal legs white with a few brown dots. Length, 68 mm.

Food-plant: Cottonwood (*Populus fremonti*).

Described from a single inflated specimen, kindly placed at my disposal by Mr. Jacob Doll, the Curator of insects in the Brooklyn Institute. A number of larvæ of *Catocala pura* were collected by Mr. Doll, in the Beaver Valley, Utah, from which he reared a series of specimens, varying from the type form with uniform grayish white fore wings, to forms more or less covered with black scales or shades, to almost uniform dark gray examples, proving that *C. pura* is a very variable species.

Catocala amatrix *Hübner.*

Lamprosia amatrix Hübner, Samml. Exot. Schmett., Bd. II, 1806, Lep. IV, Noct. III, Semigeomet. VIII, Bleph. B. Coccinæ, 2, figs. 3 (upper side) and 4 (under side).

Catocala nurus WALKER, List Lepid. Ins. Brit. Mus., Pt. XII, 1857, p. 1195.
Catocala selecta WALKER, List. Lepid. Ins. Brit. Mus., Pt. XII, 1857, p. 1197.

Hübner's figure of *Catocala amatrix* is the form with a broad dark brown basal streak on the fore wings and another similar streak from the reniform to the outer margin below the apex. Walker's *Catocala nurus* is the same as Hübner's species. The name *amatrix* was heretofore applied to the form with pale brown fore wings without the brown shades which Walker described as *Catocala selecta.* The species will have to stand as follows:

Catocala amatrix Hübner (dark form).
Syn. *C. nurus* Walker
Var. *selecta* Walker (pale form).

Catocala delilah var. **calphurnia** Hy. Edw

Catocala calphurnia HY. EDWARDS, Bull. Brooklyn Ent. Soc., Vol. III, 1880, p. 59.

The type of this form is a female in the collection of the late Dr. James Bailey, Albany, New York, and was examined by me.

The specimen looks suspiciously like an exotic species allied to the European *Catocala nymphœa* Esper or it is an undersized aberration of *Catocala delilah.* The fore wings are almost uniform dark brown with a very slight greenish tint and the transverse lines and marks are quite indistinct. The transverse anterior line is oblique and almost even. The transverse posterior line with the dentations as in *delilah.* In the hind wings the yellow central area is very narrow and the basal area is black with a slight yellow field at the extreme base. The outer margin is very broad, black, with the fringes yellow, cut with brown. The apex is yellow. Expanse 54 mm.

Habitat: Kansas.

Catocala parta var. **petulans** *Hulst.*

This variety was described from a small specimen evidently bred from an under-fed larva. It differs from *C. parta* only by being smaller and paler in color. It is not worthy of a name.

Catocala ilia *Cramer.*

Noctua ilia CRAMER, Pap. Exot., Tom. I, 1779, pl. xxxiii, p. 53, figs. C. B.

Cramer's figure of *Catocala ilia* is the dark brown form with the reniform dark and ringed with white; a few white marks on the costa, a white shade on the transverse anterior and posterior lines, and whitish subterminal line. The black band on the hind wing reaches the inner margin.

Catocala ilia var. **conspicua** *Worthington.*

Catocala uxor Guenée, Hist. Nat. Ins. Spec. Gen. Lepid., Tom. VII, Noct. Tom III, 1852, p. 92.

Catocala ilia var. *conspicua* Worthington, Papilio, Vol. I, 1881, p. 40.

Catocala ilia var. *duplicata* Worthington, Papilio, Vol. I, 1881, p. 40.

Catocala albomacula Butler, The Entomol., Vol. XXV, 1892, p. 284.

The name *uxor* Guenee (1852), is preoccupied by *Catocala uxor* Hübner (Samml. Europ. Schmett., Lepid. IV, Noct. 3, fig. 328), a European species (=*elocata* Esp.), and therefore cannot be used as a name for a variety of *Catocala ilia.* Butler (1892) mentions *Catocala albomacula* Edw. as being the form of *ilia* with the reniform spot wholly white; but I have been unable to find a description of *C. albomacula* by Edward, and the name *conspicua* Worthington will have to be used until that point is settled.

Catocala nubilis *Hübner.*

Parthenos nubilis Hübner, Samml. Exot. Schmett., Bd. II, 1806, Lepid. IV, Noct. III, Semigeom. Bleph. C. Flav. 2, fig. 3 (upper side) and 4 (under side).

Hübner's figure of *Parthenos nubilis* is the form with almost uniform dark gray brown fore wings, marked with white on the transverse posterior line at the costa, the reniform spot partly ringed with white, but very faintly so, and with slight indications of a few indistinct whitish dots in the subterminal space.

Catocala nubilis var. **fasciata**, var. nov.

In this form the median space between the transverse anterior and posterior or subterminal lines is more or less clouded or covered with white.

Catocala angusi *Grote.*

Catocala angusi Grote, Can. Ent., Vol. VIII, 1876, p. 231; Bull. Buff. Soc. Nat. Sci., Vol. III, 1877, p. 188, pl. V, fig. 1; Angus, Papilio, Vol. IV, 1884, p. 36.

This species was described by Grote from specimens sent to him by James Angus, bred from larvæ collected at West Farms, New York City. Grote's description incorporates three distinct forms of *C. angusi,* as already pointed out by James Angus (Papilio, IV, p. 36). In the Angus Collection is a fine series of *C. angusi,* including a type male. This type is the form with plain gray fore wings with a black mark at the lower angle of the transverse posterior line at the inner margin, and I propose that this form be considered the type of *C. angusi.* It is the one figured by Grote in the Bulletin of the Buffalo Society of Natural Sciences, Vol. III, pl. V. fig. 1.

Catocala angusi var. **edna**, var. nov.

Catocala angusi Grote (in part), Can. Ent., Vol. VIII, 1876, p. 331; Bull. Buff. Soc. Nat. Sci., Vol. III, 1877, p. 188, pl. v, fig. 2; Angus, Papilio, Vol. IV, 1884, p. 36 (form *B*).

This is the form figured by Grote (Bull. Buff. Soc. Nat. Sci., Vol. III, 1877, pl. V, fig. 2) which has on the fore wings a distinct, rather broad streak in the middle, running from the base across the anterior transverse line to the subreniform mark. Otherwise it is like the type form.

Habitat: West Farms, New York City.

Described from ten specimens in the Angus Collection, American Museum of Natural History.

Catocala angusi var. **lucetta** *Hy. Edwards.*

Catocala residua var. *lucetta* Hy. Edwards, French, Synop. Catocala Illinois, III, 1881, p. 4.

Catocala angusi Angus, Papilio, Vol. IV, 1884, p. 36 (var. *b*).

Catocala angusi var. *lucetta* Hulst, Bull. Brooklyn Ent. Soc., Vol. VII, 1884, p. 55.

Catocala flebilis Holland, Moth Book, 1903, p. 262, pl. XXXI, fig. 11.

Two types from Carbondale, Illinois, collected by G. H. French, are in the Hy. Edwards Collection in the American Museum of Natural History and are labeled *Catocala residua* var. *lucetta* Hy. Edw. In the Augus Collection are twelve fine specimens of the same variety bred from larvæ the same as those producing the type form of *C. angusi* and variety *edna*.

Lucetta is the form with a very broad black shade on the fore wing; it commences at the base and runs to the outer margin below the apex. The band is, as a rule, more or less interrupted by the reniform and subreniform.

Catocala judith *Strk.*

Catocala judith Strecker, Lepid. Rhop. Het., 1874, p. 95, pl. xi, fig. 5 (Aug. 1874).

Catocala levettei Grote, Trans, Am. Ent. Soc. Vol. V, 1874, p. 95 (Sept. 1874).

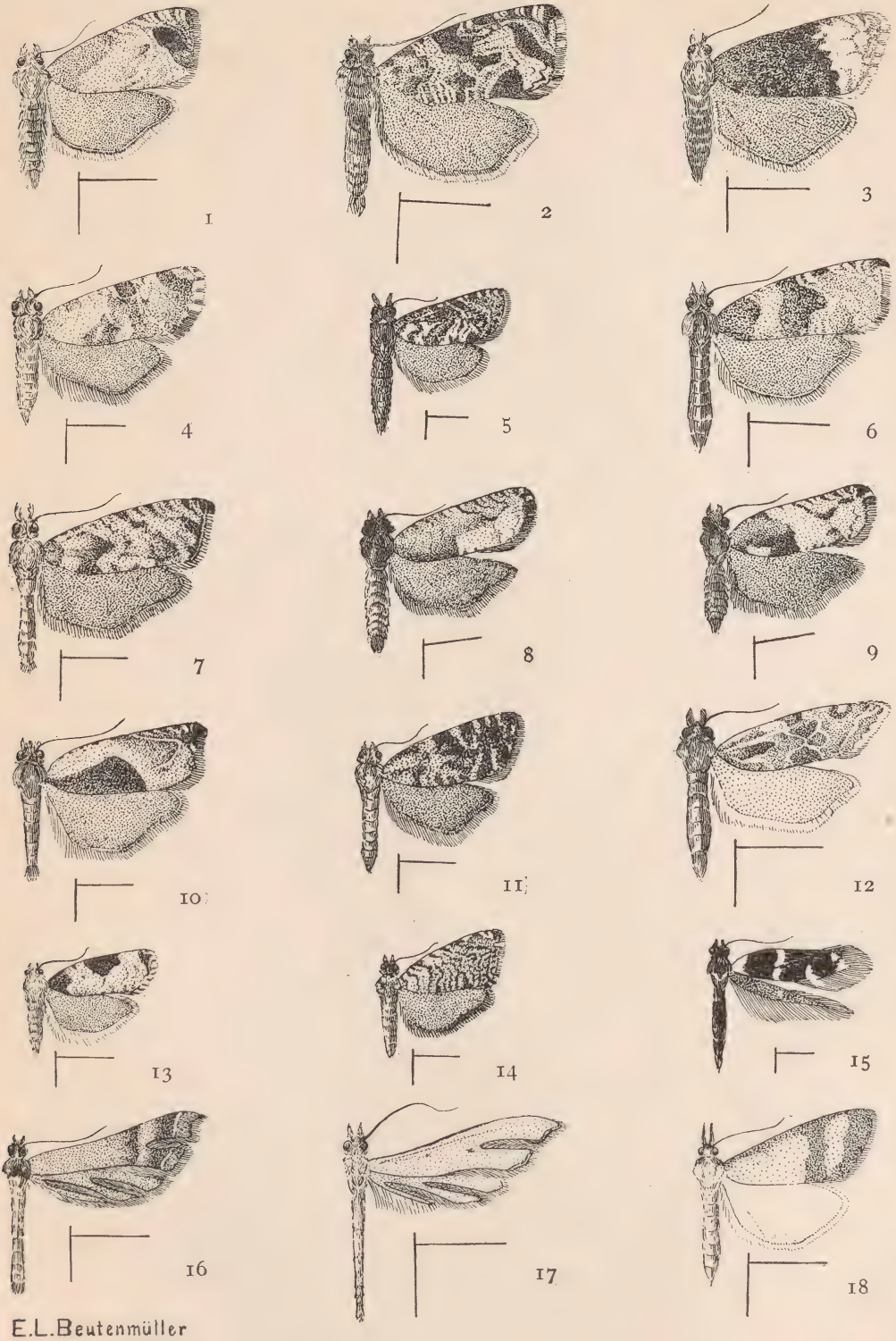
Catocala orba Kusnezov, Rev. Russe d' Entomol., Vol. III, 1893, pp. 166–168, figs.

The male and female types of *Catocala judith* Strecker are in the Angus Collection, and the species described as *Catocala orba* is without a doubt the same as *judith*. The published figure of *C. orba* corresponds exactly with the specimens of *C. judith* in our collection.

Catocala staudingeri *Beuten.*

Catocala aspasia Staudinger, Iris, Vol. IX, 1896, p. 400.

The name *Catocala aspasia* used by Staudinger for a species from Mardin, Turkey in Asia, is preoccupied by *Catocala aspasia* Strecker, (Lepid. Rhop. Het., 1874, p. 94) and I propose for it *Catocala staudingeri*.



New Species of Microlepidoptera.

59.57.82(75.6)

Article VIII.—MICROLEPIDOPTERA FROM THE BLACK MOUNTAIN REGION OF NORTH CAROLINA, WITH DESCRIPTIONS OF NEW SPECIES.

By W. D. Kearfott.

Plate VIII.

The material forming the subject of this paper was collected in the Black Mountain region, Buncombe Co., North Carolina, by Mr. Wm. Beutenmüller, during the several expeditions he has made to this interesting region under the auspices of the late Dean Hoffman, afterwards continued by his son Mr. Samuel V. Hoffman.

Altogether more than 140 species of microlepedoptera have already been determined, which number will be increased when all of the material is worked up. A complete list will appear in Mr. Beutenmüller's report; in the following pages reference is only made to the species supposedly new to science and to such others as have been bred or on which comparative notes are thought necessary.

The opportunity has been taken to figure five species, nos. 6, 7, 14, 16, and 18, not very well known, and which have not been figured before in this country.

I am indebted to Mrs. Beutenmüller for the easily recognized drawings, reproduced on the plate, and also for many of the larvæ which she took much interest in collecting. I have also to acknowledge the help of Dr. Dyar in identifying several Phycits and the assistance of Mr. Busck with several of the Gelechids.

Cotypes of all of the new species are deposited in the Collections of the American Museum of Natural History, and in my collection.

Pyrausta fissalis *Grote.*

Two specimens, one bred from larva on leaves of sassafras and one on goldenrod; received May 28 and June 1; in pupa June 8; issued June 21. Larva 28 to 30 mm. long, cylindrical, tapering very much to each end; grayish yellow, shining, tubercular plates large, shining, stained with brown around the edges. ia and ib joined in shape of figure 8. Head and P. T. shield pale brown. Pupated in slight web in crumpled leaves. Pupa very dark brown.

Pyrausta æglealis *Walker.*

One specimen, bred from larva on butternut, received June 15, issued July 16.

Larva shining, wet looking, semitransparent, pale yellow, brownish red dorsally on segments 3 to middle. Head small, triangular, pale brown, mottled with darker brown. P. T. shield same, with large dark brown patches on either side of dorsal line, on posterior edge, extending down to spiracles and forming a distinct collar. Dorsal tubercles on metathoracic segment on large brown plates. Lateral plates on segments 4, 5, and 6 also large and much darker than skin; other plates large but concolorous.

Folds leaf into large cell or cavity; frass not ejected, but compressed into a large moist mass.

Pyrausta signatalis *Walker?*

One specimen, Valley, June 26. All other specimens I have seen of Walker's species are a uniform shade of pink. This specimen is heavily shaded with reddish brown, with a broad ciliate ochreous band; the white transverse lines are, however, exactly like typical examples.

Acrobasis caryivorella *Ragonot.*

Four specimens bred from larvæ in cases between the leaves of alder; one received May 18 had already pupated; others received June 8, pupated a few days later. Moths issued June 22 to 29. Larva leathery, dark gray or greenish black. Head reddish-brown, P. T. shield ochreous brown, both head and shield very rough, their surface seeming to be covered with minute globules; on mesothoracic segment tubercle ib is on a large black and red chitinous plate. Larval case of grains of black frass and silk, serpentine in shape when of small diameter, but becoming straighter or cornucopia like when the larva is mature. Cocoon formed by spinning a rounded cover over the end of the case, or sometimes between two leaves. A large Hymenopterous parasite was bred from one larva.

Acrobasis kearfottella *Dyar.*

One specimen, bred from larva in case between leaves of hickory, received May 28.

Larva with skin of leathery brown texture. Case of grayish white silk with an occasional grain of grass, somewhat flattened, its small diameter serpentine, enlarging into a chamber 20 mm. long by 6 mm. wide by 4 mm. thick. Pupa in cocoon spun in the large outer end of the case.

Salebria contatella *Grote.*

Two specimens bred from larvæ on locust, received May 28 and June 6. Moths issued July 4 and 7. Mature larva agrees with description by Packard, p. 361, Fifth Report of Entomological Commission; but just before pupating the green becomes dull red. Cocoon, flattened oval, spun among debris at bottom of breeding jar.

Platyptilia carolina sp. nov.

Plate VIII, Fig. 17.

Expanse 22 to 25 mm.

Head, palpi, thorax and fore wing clay yellow. The fore wing is minutely dotted with a darker shade and the costa from inner third to outer fourth is dusted with blackish scales. There is a dark brown dot below costa, about a third from base, and another on lower lobe just within and below inner end of cleft; on the apex of the second lobe is a similar spot. There is a preciliate line of blackish brown on the termens of each lobe; a paler line separates another but less dark line from the long scales of the cilia, which are pale purplish fuscous. The hind wing is the same color as the fore wing but with a faint pinkish tinge, with brownish lines before the cilia, and a tiny black dot near outer end of cilia of third lobe. The body is shaded with brown posteriorly and on the sides, with a few whitish scales in the lateral tufts. Legs bleached straw color, dusted with brown.

I have a darker specimen, where the ground color is more thickly powdered with brown, and all of the dark lines and spots are accentuated. This specimen shows a tiny brown dot at the base of the first lobe, just above the dot on the second lobe; the hind margin cilia are also mixed with black scales on the outer half. Three specimens, "Valley," May 27 to June 26.

Exartema hippocastanum sp. nov.

Plate VIII, Fig. 2.

Expanse 21 to 22 mm.

Head olivaceous brown in which are mixed blackish brown scales, face cream color. Palpi cream color, outside of tuft on second joint stained with blackish fuscous on inner half of upper edge and the lower outer end of tuft; apical joint black with a tiny whitish dot on extreme apex. Antennæ fuscous, paler within. Thorax pinkish brown in front, gray in the middle divided by a black line, behind which are pink scales tipped with white; the tuft is of long fuscous scales tipped with pink, and with several white scales inserted; patagia fuscous and pink with lateral scales white. Abdomen, first joint white, others fuscous on upper side, white on sides, ochreous white beneath, tuft ochreous.

Fore wing with the usual *Exartema* scroll-work. The inner fascia transversely

across wing at inner fourth on costa to inner third on dorsal margin, divided into two parts by a narrow broken line of brown, and each side is divided by a leaden metallic blue line; its inner edge is deeply excavated for more than half its length in the middle, the outer edge sends an oblique spur through middle of cell and is indented a quarter above dorsum. The outer fascia begins on costa a little beyond middle in the form of two outwardly oblique costal dashes, which run into a flattened ovate patch over end of cell, which sends out two spurs at right angles to each other, one to the anal angle and one to dorsum at about two-thirds from base; the latter sends a short spur obliquely upward at about the middle of its length, which almost meets the outer spur of the inner fascia. This outer fascia, like the inner, is divided by a narrow brown line and each side subdivided by leaden blue. From the costa beyond this fascia are three geminate streaks, the two inner coalescing below and sending a spur down to middle of wing at outer margin; between this spur and the margin is a vertical geminate line. The basal area, within the inner fascia, contains a roughly triangular pale patch of the same shade and construction as the fasciæ, separating this from inner fascia is the ground color. Cilia fuscous, with a black spot at apex, and two pink streaks below apex, and two pink streaks above anal angle. The dark ground color, between the fasciæ is velvety black but more or less heavily overlaid with ochreous red scales, in some specimen the overlaying scales are rich indian red. The fasciæ and spots are pale shining pinkish white and fuscous, subdivided by shining leaden or steel blue. On the costa where these pale fasciæ and spots overlay it, the color is creamy white and there are six spots of this color. In the specimens of the indian red type, the thorax and head are several shades darker than described and frequently the white scales are missing.

Hind wing olivaceous brown, cilia white and patch above cell white; underside creamy white mottled with fuscous at apex and below costa. Underside of fore wing smoky fuscous with costal spots and spots in cilia repeated.

Six specimens, bred from larvæ feeding on buckeye, collected by Mrs. Beutenmüller, May 18.

My notes on the larvæ are uncertain, as two species were in the same box but it is likely the following may be applied to this species. "About 16 mm. long, very intense green, head and P. T. shield small and jet black, slightly tapering to either end. Rolls and crumples the ends of the leaves often involving more than one leaf."

Exartema merrickanum sp. nov.

Plate VIII, Fig. 1.

Expanse 18 to 20 mm.

Head yellowish-gray. Palpi whitish yellow, with a blotch of fuscous on outer end of second joint, and a tiny dot of the same color at base, outside; apical joint black. Thorax ashy gray mixed with olivaceous scales, posterior ends of patagia and thoracic tuft white. Abdomen white on segment beneath thoracic tuft; other segments fuscous, shining; anal tuft ochreous-brown.

Fore wing grayish white and olivaceous gray, with a dark shade from base to middle of costa and a large triangular patch of indian red in apex, enclosing an oval

black spot. The usual *Exartema* scroll-work is almost obliterated in this species. There are three olivaceous patches, one on fold at inner fourth, one below fold just beyond middle, and the third before anal angle; beyond the third is a patch of whitish shining scales with reddish and brown strigulæ, involving the anal angle and forming the inner boundary for the red apical triangle. There is a paler streak from inner fourth of dorsal margin to outer fourth of costa. The inner half of costa is dotted with cream and black; in the middle of costa is a quadrate spot of red and black scales; beyond this to apex the costal dashes are red and white, with a black dusting in the red; at the outer third the costal dashes send down leaden metallic lines which curve outward and run into the pale patch at anal angle, similar lines rise from the costal dots before apex, join together and run to middle of outer margin through the red patch and outside of the black spot. A small red and black spot on the middle of the wing at the end of cell. Cilia shining pink, with a nearly black patch at apex and three or four blackish scales between apex and anal angle.

Hind wing smoky brown, cilia white; underside gray white, with a streak of smoky brown below the cell and in the apex; cilia white. Underside of fore wing smoky brown, except along costa and termen which are creamy yellow.

Forty specimens: Black Mountains, N. Car., Valley, June 12; New Brighton, Pa., June 3 to Aug. 12, F. A. Merrick; Algonquin, Ill., July 8 to 13, Dr. Nason; Iowa City, Iowa, June 29, Prof. Wickham; Chicopee, Mass., F. Knab; Pittsburg, Pa., Henry Engel.

Nearest to *E. corylanum* Fern., but the latter is smaller and the prominent dark triangle in apex is absent.

Exartema versicoloranum *Clem.*

One specimen, bred from larva on black oak, issued June 5. Ten other specimens captured in valley between June 2 to 26.

Olethreutes nimbatana, var. **montanana** var. nov.

Plate VIII, Fig. 3.

One ♀ specimen, Mt. Graybeard, June 9. Larger and darker than *nimbatana*, the outer edge of the dark area nearly vertical, not curving inward as in *nimbatana*. The apex and extreme termen is much more heavily overlaid with dark scales and streaks.

Hind wing very dark smoky fuscous, cilia broadly paler. Expanse 20 mm.

Eucosma obfuscana *Riley.*

One specimen, Valley, June 11. I quite agree with Dr. Dyar in separating this from *E. scudderiana* Clem.

Epinotia ilicifoliana sp. nov.

Plate VIII, Figs. 8 and 9.

Expanse, ♂ and ♀, 13.5 to 15 mm.

Head dull gray, shaded with brown above eyes; palpi dark gray outside, lighter gray within; antennæ dull fuscous. Thorax dull gray, mixed with brown scales, with a purplish gleam, which is particularly strong on anterior and posterior ends of patagia. Abdomen silky fuscous above, faintly tinged with purple, below shining cinereous, darker on anal joints; legs shining cinereous, fore and middle tibiæ and tarsi annulated with brown.

Fore wing grayish cinereous, in a broad band from inner half of costa to dorsal margin, which is connected with large ocellic spot of the same shade. Dorsal patch to inner third on costa and half on dorsum, boundary line dentate; dull brown on dorsal half shading into cinereous brown above, and with a small grayish cinereous patch on dorsum. The costa is marked with about eleven purplish brown dots, between each a tiny dot of the same color, separated by shining gray; beyond the middle pale stripe these dots are large and conspicuous, the inner one (at middle of wing) being extended downward to end of cell, then joining a crescent shaped dash of the same color which sends a spur into the apex; above this crescent mark the costal spots are outlined below by yellow; the dark apical spot is the largest and is hook-shaped outwardly. Before the anal angle is a small triangular brownish spot, sometimes sending a yellowish line to the crescent above it. Ocellus not distinctly defined, but the gray ocellic region covers the outer third of wing below the crescent; it is slightly strigulated with vertical rows of brown scales, a curved one before the margin being most prominent. Cilia below the apical spot, dull fuscous outwardly, shining gray within.

Hind wing smoky brown, darker toward apex, cilia paler, preceded by a dark, then a light line. Underside of both wings brown with a faint grayish pubescence, costal spots of fore wing repeated.

Larva 12 mm. long, color dull yellow, green shining through in irregular blotches on dorsal and lateral regions. Head, prothoracic shield and thoracic legs black. A large polished black tubercule just in front of spiracle and a smaller one on base of leg, on joint 2. Anal shield green, not chitinous. Prothoracic shield divided by a paler dorsal line.

This species is quite variable, and ranges to a form in which the central gray fascia is almost obsolete, the dark area covering all of the costal and inner half of wing, the gray only appearing on the outer dorsal half, below the crescent to the boundary of the basal patch.

Bred from larvæ tying and crumpling the young leaves and terminal twigs of a species of *Ilex*, probably *verticillata* Linn., collected by Mrs. Beutenmüller on Mount Graybeard, No. Car., full grown May 20, in pupa May 27, and issued between June 10 and 20. Also bred by the writer from the same food-plant in Essex County Park, N. J., with about the same dates; found on one bush only, about six feet in diameter and the same height. About the middle of May for the past six years, this bush

is covered with the webs of these larvæ, as many as one hundred having been counted at one time, but a month later almost every vestige of their work had disappeared. I have only taken one specimen on the wing July 4.

Pupate in tight, dense cocoon spun in debris, or frequently in a small flap cut out of leaf and turned under. Breeding numbers K. 212, K. 465 and K. 543 placed temporarily under *Epinotia*; the structure does not fit with any of the Tortricid genera credited to North America.

Antennæ, ♂ and ♀, slightly dentate. Palpi with a flattened, triangular tuft of closely appressed scales on second joint, outer joint very short, obtuse. not hidden. Long scales in circles above eyes, coming together above forming a slight crest between eyes and a larger posterior one on head. Thorax smooth. No tufts of raised scales on fore wing, and no costal fold in ♂. Fore wing slightly arched at base of costa and near apex, nearly straight between; apex rounded, deeply indented beneath apex, at ends of veins v and vi. Termen below evenly rounded into dorsal margin. Venation: 1 from middle of cell, 3 separated from 4, and bent downward to inner third, then upward until it approximates 4 at termen; the spaces between 4 + 5, 5 + 6, and 6 + 7 about equal; 7 from within upper angle of cell, 7 and 8 stalked for half their length, 7 to termen and 8 to costa.

Hind wing, 3 and 4 stalked for about one third, 5 approximate; 6 and 7 closely approximated at base.

Ancylis pulchellana *Clem.*

Plate VIII, Fig. 10.

One specimen, Valley, June 2. This species has always been in our lists under the genus *Proteopteryx*. The type is in the collection of the American Entomological Society, Philadelphia; it is very close to *A. laciniana* Zell. and *A. dubiana* Clem.

Enarmonia eclipsana *Zell.*

Four specimens, summit of Mt. Graybeard, May 26, and Valley, June 3. This species was omitted by Fernald in his original Catalogue of North American Tortricids, 1882, and apparently for the same reason has been omitted from all subsequent lists, notwithstanding a very beautiful figure of the species is given by Zeller in Verh. zool.-bot. Ges. Wien. plate IX, Fig. 29, 1875.

Hemimene nigromaculana sp. nov.

Plate VIII, Fig. 5.

Expanse 11 to 13 mm.

Head clay brown, crests above eyes olivaceous brown, under side of face whitish.

Palpi cream color, with outer half of tuft on second joint dull black; a small black dot at base of first joint, above. Antennæ fuscous, paler between joints. Thorax olivaceous, posterior end of patagia cream color. Abdomen olivaceous brown, anal tuft cream; legs creamy white, dusted with brown.

Fore wing: — Scales black at base, ochreous at tips, causing the ground color to appear as fine vertical strigulæ of ochreous on a black ground. From the middle of the dorsal margin four white lines converge towards the upper end and terminate at middle of wing, slanting outwardly to end of cell; the two middle lines are the most distinct, the outer ones being somewhat broken and not quite reaching the apex of the cluster. Between these and base, on dorsal margin, are two shorter white lines, inwardly oblique ending at fold, they are somewhat angulated with a tendency to turn outward at the upper end. On the costa before the middle are two pairs of white dashes, resting on the costal fold, from the outer pair a shade of blue continues to the apex of the cluster of white lines. Beyond the middle another pair of white costal dashes gives rise to a metallic blue line which curves outward and inward before the termen to the anal angle, enclosing at the end of the cell a rounded ochreous yellow spot divided by three horizontal black lines. On the outer fourth of costa are three single white dashes, the middle one sending off a blue metallic line which ends beneath the apex on the termen; a few blue scales outline each of the other two dots. On the extreme outer margin are five velvety black dots, the two upper ones being separated by a white dash, the outer end of which overlaps the cilia. There are two white dots on the lower side of the ochreous patch at end of cell, with a spur from the long blue metallic line enclosing the outer one. The male costal fold is nearly half the length of the wing. Cilia shining fuscous preceded by a paler line.

Hind wing: — Smoky brown, paler towards base, cilia fuscous preceded by a paler shade; underside the same with a whitish shade over the cell. Underside of fore wing shining bronze brown, dotted with white along costa, and the cilia cut with a white dash below the apex.

Two specimens: "Valley," June 1.

Lipoptycha albolineana sp. nov.

Plate VIII, Fig. 11.

Expanse 13.5 mm.

Head olivaceous brown, face and palpi light clay brown. Antennæ pale clay brown, darker between joints. Thorax dark gray; abdomen black above paler beneath, anal tuft clay brown; legs the same with tarsi powdered with blackish scales.

Fore wing: — Dingy brownish black, with several sordid white transverse lines. At inner third a geminate white line from costa to dorsum; just beyond middle a short oblique line goes to middle where it nearly joins a similar line from costa beyond; the two form a rough triangle enclosing a spot of ground color of the same shape, below the lower ends of these two lines is a vertical white line from dorsal margin, slightly outwardly oblique. On the outer fourth of costa are two shorter white lines, the outer one curving under the apex. From the anal angle a similar white line runs to lower end of cell. The black preciliate line is cut by four or five small whitish dashes.

Cilia gray, overlaid with smoky brown scales outwardly. Hind wing and underside of both, dark smoky brown, cilia paler, and the white costal spots repeated on fore wing.

Two specimens, "Half-way-place," June 8.

Archips rileyana *Grote.*

Many specimens, bred from larvæ, in communities, webbing together masses of the leaves of horse-chestnut. Received June 4; majority in pupa June 8; moths issued June 24 to 30. At least two hymenopterous parasites bred.

Tortrix albicomana *Clem.*

Two specimens bred from larvæ received May 28, mixed with the larvæ of *Telphusa latifasciella* Cham. From huckleberry.

Eulia juglandana *Fern.*

Five bred specimens. Two lots of larvæ received May 28 and June 8, on leaves of hickory; one larva on leaves of *Viburnum acerifolium* received June 15. The moths issued from the former June 18 to 23 and from the latter July 1.

The larvæ on both food plants were alike, 23 to 24 mm. long, cylindrical slightly tapering yellowish green, darker along dorsal line; head dirty yellow, marked with brown lines and dots on sides of lobes. P. T. and anal shields not chitinous.

Larvæ on hickory, live between two leaves, or between the two surfaces of one leaf folded over, using a considerable quantity of silk. Pupated in a fold of leaf in a rather dense, white silk cocoon.

Phalonia ednana sp. nov.

Plate VIII, Fig. 13.

Expanse, ♂ and ♀, 13 to 14 mm.

Antennæ golden brown, dark brown at base, biciliated in male. Head grayish ochreous, darker above eyes and mixed with dark scales in front. Palpi grayish ochreous within, with a line of dark brown scales on upper edge, outwardly the latter color, outer joint short, obtuse, black except extreme apex which is yellow. Tuft on second joint rather narrow, long, projecting slightly forward in points above and below third joint, but not concealing it. Thorax smooth, with flattened, slight, posterior tuft; dark brown, the tips of the posterior scales and scales of patagia

ochreous. Abdomen gray, with a purplish hue on middle segment, anal tuft ochreous. Legs pale gray, annulated with dark brown.

Fore wing: — Cinereous or yellowish gray, with a blackish spot covering basal area and another on costa at middle. The gray ground color is stained with pale yellowish ochreous and faintly tinged with reddish brown on apical third and below costal spot. The basal spot is outwardly rounded extending to inner fourth at middle, slightly indicated at lower median vein, it and the costal spot are very dark brown, on which are superimposed a few reddish brown scales. The costal spot is about the same size as basal spot, about one fourth length of wing on costa, extends down to middle of wing. On the dorsum are six or seven brownish fuscous spots, a faint strigulæ of fuscous ascends toward costa from each, those in the middle of the wing, running into the costal spot are most distinct, the middle one forming a prolongation of the lower apex of the spot and is edged with yellowish. In the apical part of wing is a long sinuate line, broadest at costa, extending down to below middle of wing and ending at termen, composed of fuscous and reddish brown scales. Cilia yellowish gray, interrupted by a few fuscous scales. Underside smoky brown, light cinereous on costa beneath the paler spaces of upper surface. Hind wing above dark gray, cilia a shade paler; beneath pale gray with brown vertical reticulations, cilia paler.

Described from about forty specimens from the following localities: Half-way place, Black Mountains, N. Car., June 29; Chinchilla, Pa., June 26 (A. E. Lister); Hazleton, Pa., July 12 to 28 (W. G. Dietz); Wyoming Co., Pa., 2300 elevation (Lister and Kearfott); Warren, Mass., July 12, (Kearfott); Center Harbor, N. H., No. 18.387 (H. G. Dyar); Ottawa, Can., July 10 (C. H. Young). Named in honor of Mrs. Edna L. Beutenmüller, who not only makes beautiful drawings of insects, but collected most of the larvæ, the notes of which appear in this paper.

In Wyoming Co., Pa., I found the species fairly abundant, flying close to the ground and usually alighting on twigs or the blackened stumps of a burnt over spruce forest; between the showers on a rainy day the majority of the specimens were found resting on these stumps. At Warren, Mass., they were found in a small woods of spruce and hardwood trees, flying close to the ground and usually alighting on twigs or on the ground.

The venation agrees with Meyrick's figure of *Phalonia*, excepting 3 and 4 of hind wings are connate, hence the species will later be transferred to a different genus.

Phalonia hoffmanana sp. nov.

Plate VIII, Fig. 4.

Expanse 12 mm.

Head and thorax blackish brown mixed with paler brown scales. Palpi pale brown with a few darker brown scales on outside of second joint and on third joint. Antenna fuscous, paler at base. Abdomen blackish brown, anal tuft ochreous. Legs cream colored dusted with brown.

Fore wing: — Olive and dark brown, with patches and lines of iridescent pinkish ochreous, raised scales. The basal patch, which extends to middle of costa and inner fourth of dorsal margin, is pale pinkish brown or pinkish ochreous, with a small rectangular brown spot on the costa at inner fourth, containing two small black dots, there are four small black dots on costa on each side of this brown spot in the pale basal area. Below the costa the pale color is lightly dotted with darker brown. Beyond this area, and occupying the middle third of the wing, is a large triangular dark brown area narrow on costa but extending to anal angle on dorsal margin. It contains numerous vertical black strigulæ and two small patches of pinkish ochreous scales on each side below the fold, and is margined on costa by black dots. Beyond it a narrow, angulated band of pinkish ochreous scales starts from costa at outer fourth and runs obliquely to anal angle; this line is interrupted on end of cell by a small patch of dark brown scales. Beyond this is a flattened lunate patch, extending from a little below costa to anal angle, of olivaceous brown, horizontally streaked with black. Between this and the apical margin is a larger lunate patch of rich brown, also lined with black; this involves the costa before the apex and extends down to middle of outer margin; the two lunate patches are separated by a broken line of iridescent scales, a line of the same outwardly defines the dark brown patch and is continued as an antimarginal line into the anal angle. The cilia is ochreous brown overlaid with fuscous and preceded by a broken line of black scales. All of the pinkish ochreous scales are shining, iridescent; those on the outer half of the wing are raised in clusters and lines. The most conspicuous tuft is in the middle of the wing at the end of the cell and another just before the anal angle below the fold.

Underside of fore wing, very dark blackish brown, with four whitish dots on outer half of costa; cilia ochreous brown, with three blackish patches and preceded by a blackish line inside of which is a narrow ochreous line.

Hind wing: — Rich smoky brown, cilia leaden metallic, shaded darker inwardly and preceded by a fine yellowish line. Underside blackish brown, with whitish vertical strigulæ.

Four specimens, Mount Graybeard, May 2; Valley, June 3 to 12.

Named in honor of Dean Hoffman, whose interest and love of science has made possible the discovery of this and many other species.

Phalonia obliquana sp. nov.

Plate VIII, Fig. 12.

Expanse 20 to 22 mm.

Head clay yellow, a shade darker on tufts behind the eyes. Palpi clay yellow, shaded with brown outwardly and with a white patch on the upper side of second segment. Thorax olivaceous yellow, patagia clay yellow and whitish at base. Abdomen and legs clay yellow, the latter speckled with brown, the dark color predominating on the first two pairs.

Fore wing: — Clay yellow, with rich cinnamon brown spots and lines. There is a large kidney shaped patch of brown in the middle of the wing, with the small end resting on the middle of the costa and the lower end, which is pointed, on the

middle of the wing, separated from the lower end by a line of shining whitish scales is a small oval shaped spot; these two spots form an oblique fascia from middle of costa towards the anal angle but do not reach below lower vein of cell; obliquely inwardly is a triangular brown spot on the dorsal margin, which is a continuation of the fascia but separated from the spots above by a streak of clay colored scales. There is a long streak of brown from base nearly to middle of wing, a shade of the same color from base along dorsal margin, and another shorter streak from base along costa. Between the middle and largest basal streak and the triangular dorsal patch is a diamond-shaped patch of brown, separated on both sides by shining white lines. There is a submarginal line of brown from anal angle to apex, unevenly indented on the outer side between the veins. Between this line and the middle fascia there is a patch of brown scales becoming paler towards costa, and on costa between outer fourth and apex is a small lunate spot enclosing a small dot of clay yellow. Another small dash of brown at end of vein eight. The pale spaces on upper fourth of wing on each side of middle fascia are shining whitish yellow scales, and on the costa are marked with three of four brown specks before and about half a dozen beyond the fascia. The lines separating the various brown spots and patches are usually of the shining whitish scales. Cilia clay yellow.

Hind wing shining cinereous, darker at apex and on outer ends of veins; cilia whitish except at apex, shaded with cinereous. Underside whitish, with a few scattered darker scales along the veins. Underside of fore wing coppery brown, clay yellow along costa and cilia.

Twelve specimens, Black Mountains, N. Car., "Valley"; Hastings, Fla.; Winnipeg, Manitoba, Hanham.

The Florida specimens are somewhat paler than the description; the dark brown being largely replaced by the ground color, but the outlines of the spots and fascia can be seen by the shining whitish boundary lines.

The apex of the fore wing is pointed, termen straight and oblique, all veins separate but three and four very close together at origin, seven to termen and its origin close to eight. Hind wing three and four rather widely separated, six and seven stalked.

Telphusa latifasciella *Cham.*

Eight specimens, bred from larvæ on huckleberry, webbing and tying together the tender young leaves. Received May 28, issued June 10 to 21.

Larva 10 to 12 mm. long, slender, yellowish white, green on dorsal line; head and P. T. shield pale yellow.

Gelechia unctulella *Zeller.*

Eleven specimens, bred from larvæ webbing together the leaves of common locust. Larvæ received May 28 and June 6, moths issued July 10 to 21.

Larva slender, tapering, pale green, with three darker stripes on each side, the width of the pale and dark stripes about equal. Head and P. T. shield dull yellow; anal shield not chitinous. Length 14 to 15 mm. Just before pupating the pale green becomes pinkish red and the darker stripes purplish red.

Pupa in a snug little cocoon between two or more leaves; shining chestnut brown, much broader across thorax than elsewhere, evenly tapering to anal end.

Gelechia vernella *Murtf.*

Fifteen specimens, bred from larvæ on leaves of black oak; received May 24, issued June 10 to 15.

Larva slender, tapering, pale green, with three darker stripes of equal width on each side. Head, P. T. shield and thoracic feet jet black; a broad, dull brown band on posterior half of second thoracic segment, extending its entire circumference. Anal shield not chitinous. Length about 12 mm. The green color becomes reddish when mature. Pupa shining, pale brown, in a web between the leaves. Some of the larvæ were badly infested with a minute dipterous parasite.

Depressaria pulvipennella *Clem.*

Two specimens, bred from larvæ webbing the young leaves of a species of *Eupatorium*; received June 13 and 25; moths issued July 9 and 15.

Depressaria robiniella *Pack.*

Two specimens, bred from larvæ webbing the leaves of common locust; received June 6 and 16; moths issued July 1 and 4.

Depressaria lythrella *Wlsm.*

Two bred specimens; larvæ received June 27, webbing the leaves of a low shrub (identity not known); moths issued July 20. Larva dull whitish green, no lines or stripes; pupating in debris in bottom of breeding jar in a slightly built cocoon.

In Walsingham's description of this species, he states that the larvæ are found in the leaves of *Lythreum alatum* (Illinois). These North Carolina specimens agree closely with Walsingham's description, except that they are a trifle larger,— 17 mm. instead of 15 mm.

Œcophora newmanella *Clem.*

Thirty-eight specimens, all flown, summit of Mt. Graybeard, May 26, and Valley May 28 to June 8. The variation in this long series is considerable, ranging from the form with prominent and well defined basal streaks to examples with the streaks almost obsolete, represented by a few ochreous scales only.

Antispila *Hübner.*

Synopsis of Species.

With white apical spot		1.
No apical spot		2.
1, Outer joints of antennæ white		*hydrangiœella* Cham
Not white		*ampelopsiella* Cham.
2, With no dorsal or costal spot		*eugeniella* Busck.
With dorsal and costal spots		3.
3 Costal spot extended into an angulated fascia		*major* Kearf.
Costal spot of moderate size		4.
4, Fascia and spots golden hued		5.
Fascia and spots silvery white		*viticordifoliella* Clem.
5, Fore wings reddish coppery on outer half		*cornifoliella* Cham.
Fore wings not coppery		6.
6, Fore wings purple brown, without greenish reflection		*isabella* Clem.
Fore wings dark brown with greenish reflection		*nyssæfoliella* Clem.

Antispila major sp. nov.

Plate VIII, Fig. 15.

Alar expanse 9 mm.

Head, face, palpi, abdomen, and legs shining grayish bronze. Thorax shining bronze, not gray. Antennæ, basal and apical third brown, middle third silvery white.

Fore wing bronze brown, slightly shining. Spots and fascia pale golden, shining, the scales of the spots somewhat raised and occur as follows: Base broadly metallic, from costa to dorsum, outer edge inwardly curved. Fascia at inner third nearly straight, not wider on dorsal than costal margin, constricted at fold, and nearly separated into two spots of about equal size. Dorsal dash at outer third narrow, oblique outwardly to middle of wing, the metallic scales overspread the cilia, equalling in size and shape the spot on wing. Costal dash at apical fourth, obliquely inward to cell, thin angulated outward to anal angle, where it expands into a triangular blotch, roughly shaped like the letter S. Hind wings and cilia of both gray brown, not metallic.

Three specimens, Black Mountains, N. Car., "Valley," June 2, 8 and 10.

Gracilaria sassafrasella *Cham.*

Four specimens, bred from larvæ forming the characteristic cones on the leaves of common sassafras. Received June 9, issued June 22 to 29.

Larva 7.5 mm. long, slender, lemon yellow, head light brown, only three pairs of abdominal legs, or four pairs including anal claspers. Pupates under yellow silk cocoon, spun in a wrinkle of a leaf or in the angle of a box.

Epimartyria auricrinella *Wlsm?*

Two specimens, Valley, June 1. Too badly rubbed to be absolutely certain of specific identity; one specimen has an ochreous head with wing expanse and general color scheme of *auricrinella*; the head of the other is entirely denuded.

EXPLANATION OF PLATE VIII.

Fig. 1. — *Exartema merrickanum* Kearfott.
2. — *Exartema hippocastanum* Kearfott.
3. — *Olethreutes nimbatana* var. *montanana* Kearfott.
4. — *Phalonia hoffmanana* Kearfott.
5. — *Hemimene nigromaculana* Kearfott.
6. — *Exartema versicoloranum* Clemens.
7. — *Thiodia signatana* Clemens.
8. — *Epinotia ilicifoliana* Kearfott.
9. — *Epinotia ilicifoliana* Kearfott.
10. — *Ancylis pulchellana* Clemens.
11. — *Lipoptycha albolineana* Kearfott.
12. — *Phalonia obliquana* Kearfott.
13. — *Phalonia ednana* Kearfott.
14. — *Hemimene incarnana* Clemens.
15. — *Antispila major* Kearfott.
16. — *Platyptilia acanthodactyla* Hübner.
17. — *Platyptilia carolina* Kearfott.
18. — *Diasemia roseopennalis* Hulst.

56.9(1182:78.3)

Article IX.— A LOWER MIOCENE FAUNA FROM SOUTH DAKOTA.

By W. D. Matthew.

One of the principal desiderata of students of fossil mammals in this country has been the discovery of a fauna which should connect up the latest of the White River with the earliest of the so-called Loup Fork faunæ of the Western Plains. A considerable gap in time separated the two, and the intervening sediments are as a rule very barren, and have yielded but a scanty fauna. This gap is in part filled, in the opinion of most authorities, by the John Day formation of Oregon. But the John Day fauna is much more nearly allied to the White River than to the earliest Loup Fork faunæ, and the geographical separation and different conditions of deposition of this formation from those of the Plains made it uncertain how far its faunal differences from the upper White River might be explained as varying facies of a contemporary fauna rather than indications of later age.

The first intermediate fauna found east of the Rockies was obtained from the beds underlying the Deep River beds (lower Loup Fork) in Montana, and described by Scott in 1893. Prof. Scott regarded it is equivalent to the upper John Day (*Promerycochœrus* beds). The exposures however were limited and the fauna a scanty one. In 1901 and subsequent years Hatcher and Peterson conducted a vigorous and successful search on behalf of the Carnegie Museum in the formations overlying the White River in Sioux Co., Nebraska, and in 1905 the great Agate Spring fossil quarry was discovered and worked with extraordinary success. Mr. Hatcher published some geological observations upon these beds in 1902, but his untimely death prevented his sharing in the appreciation of their age and important position in the faunal series, which could only be understood after preparation and study of the specimens was more advanced. The prosecution of this work is now in the able hands of Mr. Peterson, who has already published two important memoirs and several minor papers dealing with this new and interesting fauna.

In 1902 and 1903 the American Museum parties collecting in the Loup Fork of South Dakota, south of White River, made a brief reconnaissance of the beds lying between the Loup Fork and White River formations, and found a few fossils sufficient to indicate their age as Lower Miocene, and the local term of Rosebud beds was proposed by Matthew and Gidley

for this intermediate formation. In 1906, when the work in this region was resumed, Prof. Osborn authorized a thorough search of these rather barren and unpromising beds, in view of the probable importance and interest of whatever fossils might be found in them. The results of the first season's work have fully justified Osborn's decision, the fauna being almost entirely new, and supplying two intermediate stages of evolution between the Oligocene and later Miocene. Although probably nearly equivalent in age to the Agate Springs fauna it presents a very different facies, as far as comparisons have been made. Only a small part of the collection has yet been studied and compared in the museum; for the remainder the determinations are those made by the writer in the field, and are merely approximate and in no case specific. The results already attained, however, seem of sufficient interest to warrant their publication, especially desirable in connection with Prof. Osborn's forthcoming correlation of the mammal faunæ of the American Tertiary and Quaternary.

The western part of the formation attains a thickness estimated at 500 feet on Porcupine Creek, a southern tributary of White River. The base is taken at a heavy white stratum which appears to be identical with the stratum capping the White River formation on Sheep Mountain in the Big Badlands. This stratum can be seen extending interruptedly across the river to Sheep Mountain about twenty miles distant, capping several intervening buttes and projecting points of the underlying formation. The Rosebud beds at the bottom approximate the rather hard clays of the upper Leptauchenia beds, but become progressively softer and sandier towards the top, and are capped at Porcupine Butte[1] by a layer of hard quartzitic sandstone. Several white flinty calcareous layers occur in the beds, one of which, about half-way up, was used to divide them into Upper and Lower. The stratification is very variable and inconstant, lenses and beds of soft fine grained sandstone and harder and softer clayey layers alternating with frequent channels filled by sandstones and mud-conglomerates, all very irregular and of limited extent. The hard calcareous layers are more constant. A bed of volcanic ash lies near the top of the formation and there may be a considerable percentage of volcanic material in some of the layers further down. These volcanic ash beds should in theory be of pretty wide extent, and may be of considerable use in the correlation of the scattered exposures on the heads of different creeks — a very difficult matter without their aid.

These beds form the upper part of the series of bluffs south of the White

[1] An isolated butte at the "Bird" head of Porcupine Creek, which is a well known landmark in this neighborhood. It appears to be misplaced or wrongly identified in Darton's usually accurate map.

River on the Pine Ridge and Rosebud Reservations and are exposed in the upper part of the various tributary creeks. The name Arickaree[1] has been applied by Darton to these and various more or less similar formations overlying the White River in the Central Great Plains. In northeastern Colorado the Arickaree beds are known from their fauna to be middle or late Miocene; in the bluffs south of White River in South Dakota they are Lower Miocene — possibly in part Oligocene; for the most part their age is unknown. Hence the term Arickaree, if Darton's connotation of it be accepted, must be used in a broad way — somewhat as Loup Fork has been used by most writers — to signify deposits of similar lithologic character and stratigraphic position, but of quite different age in different parts of the Plains. Terms of more local application and more exact meaning are necessary for palæontologic work, and their wider correlation on faunal grounds will progress hand in hand with determination of their exact position in the general geological scale. By the time we can be sure, for instance, that the Rosebud beds are contemporaneous with the Fort Logan beds of Montana, we will also be sure of their precise position in the Miocene or Oligocene. Continental deposits of fluviatile origin are of necessity scattered, discontinuous, and of varying age in different sections, and by their very nature do not admit of the widespread correlations of marine deposits in which uniform conditions and continuous deposits may prevail over wide areas. The exact equivalence of two deposits in separated areas is, when it occurs, a mere coincidence, and for satisfactory comparison of faunas the attempt to extend minor subdivision names over wide areas leads merely to confusion.

Lower Rosebud Fauna.

The following species have thus far been identified from the Lower Rosebud beds:

CARNIVORA.

Nothocyon gregorii sp. nov.
" *vulpinus* sp. nov.
Mesocyon robustus sp. nov.
Enhydrocyon crassidens sp. nov.
Nimravus sectator sp. nov.

RODENTIA.

Entoptychus formosus sp. nov.
" ?*curtus* sp. nov.

[1] Dr. Hay has called my attention to the fact that the term Arickaree has been previously applied by Cragin to a subdivision of the Cretaceous and should not therefore be used for a Tertiary formation.

Steneofiber ? pansus Cope.
" *simplicidens* sp. nov.
" *sciuroides* sp. nov.
" *brachyceps* sp. nov.
Euhapsis gaulodon sp. nov.
Meniscomys sp.
Lepus sp.

PERISSODACTYLA.

Parahippus sp.
Anchitherium sp.
Diceratherium sp. div.

ARTIODACTYLA.

Elotherium sp.
Eporeodon sp. div.
?Mesoreodon sp.
Promerycochœrus sp. div.
Leptauchenia sp.
Hypertragulus ordinatus sp. nov.

Upper Rosebud Fauna.

The fauna of the Upper Rosebud is almost entirely distinct, few species passing through.

CARNIVORA.

Cynodesmus thomsoni sp. nov.
" *minor* sp. nov.
Megalictis ferox gen. et sp. nov.
Oligobunis lepidus sp. nov.

INSECTIVORA.

Arctoryctes terrenus gen. et sp. nov.[1]

RODENTIA.

Heteromyid gen. indet.
Entoptychus curtus sp. nov.
" *?formosus* sp. nov.
Lepus macrocephalus sp. nov.
" *primigenius* sp. nov.

PERISSODACTYLA.

Parahippus
"
Diceratherium

[1] Chrysochlorid, gen. indet., Matthew, Science, N. S., Vol. XXIV, p. 786, Dec. 14, 1906.

ARTIODACTYLA.

Desmathyus pinensis gen. et sp. nov.
Merychyus sp. nov.
Merycochoerus sp.
?*Miolabis* sp.
Blastomeryx advena sp. nov.

Comparison with American Oligocene and Miocene Faunae.

The Rosebud fauna is very clearly related to the John Day. The great majority of the species in the lower Rosebud and many of those of the upper beds can be referred to John Day genera but show, whenever adequate comparison can be made, a very considerable advance upon the species of the John Day. The rest of the species show a sufficient advance upon John Day or White River species for generic distinction, but the entire fauna is an outgrowth of the Oligocene (White River and John Day) faunæ and contains no new (immigrant) elements, with the single exception of *Blastomeryx*. Comparison with the Middle and Upper Miocene faunæ is more difficult on account of our imperfect knowledge of so many of the species. For the most part they appear to be a further outgrowth of the Rosebud fauna, but contain several new elements which cannot be derived from this source. The most prominent of these are the Proboscidea, the Pecora (modernized ruminants), the Protohippinæ[1] (horses with long-crowned cemented teeth and reduced lateral metapodials but retaining a vestigial pollex), and probably certain phyla among the Carnivora (Lutrinæ, etc.). Aside from these foreign elements of the later Miocene, the Rosebud fauna presents two stages in the evolution of the Miocene fauna, fairly intermediate between the John Day and the Deep River-Pawnee Creek. A considerable number of the genera of the Upper Rosebud are found in the Deep River or Pawnee Creek beds; the remainder are sufficiently more primitive for generic separation or represent phyla that have not survived. If the John Day represents the Upper Oligocene of Europe and the Deep River-Pawnee Creek the Middle Miocene, the Rosebud represents an earlier and a later phase of the Lower Miocene. Stratigraphically it appears to be continuous with the White River formation, and I do not think there is any considerable break between them. But the fauna is much closer to that of the John Day than to the highest known White River fauna (Protoceras beds). There is, however, a considerable thickness of barren clays (Upper Leptauchenia beds) overlying the fossiliferous Pro-

[1] Gidley, unpublished.

toceras beds, and it is probable that these barren clays, in which hardly anything but *Leptauchenia* has been found, represent the John Day or Upper Oligocene stage. The difference in thickness is rather startling, the John Day being 1800 feet thick while the Upper Leptauchenia beds are about 100 feet. But the John Day is a volcanic ash and tuff formation, probably of comparatively rapid deposition, while the deposition of the Oligocene and Miocene series on the Central Plains was in most places comparatively slow, measured by the faunal change from one level to another, and this is especially true where it is composed exclusively of very fine clays.

The discovery of these intermediate stages will enable us to clear up the relations of most of the Oligocene and Upper Miocene genera and to trace the descent of the various phyla and subphyla much more exactly than has hitherto been possible. The more elaborate studies and extensive collections of the past few years in the American Tertiaries have shown that the simple phyletic series, based upon more fragmentary and imperfect data than are now available, are true only in a general and approximate way. Recent phylogenetic study has tended quite as much to negative as to positive results — to break up accepted phyla as much as to reinforce them by more complete knowledge of the morphology of the genera. It is peculiarly satisfactory therefore to find a fauna which is intermediate between two stages hitherto disconnected, and enables us to perceive the exact relationships between genera which could until now be connected only in a general or provisional way. The preliminary results here presented are very incomplete, and various additions and modifications may be needed when the collections are more completely prepared and studied. But some relations are already tolerably clear.

Among the Carnivora, the Rosebud species referred to *Nothocyon*, *Mesocyon* and *Cynodesmus* bridge the gap between these genera, those from the lower beds being somewhat nearer the earlier forms, while the upper beds species are closer to the more advanced type of *Cynodesmus*. Their dentition is very like that of modern Canidæ, in brain and foot structure they are very different, and much nearer to the Oligocene Canidæ. The aberrant Oligocene Canid *Enhydrocyon*, and *Oligobunis*, which is more probably a Musteline, survived into the Lower Miocene.

With *Oligobunis* is found in the Upper Rosebud a larger and more advanced genus of Mustelines which bridges the gap between the primitive Mustelidæ of the Oligocene and the modernized forms of the later Miocene and more recent formations. The *Dinictis* phylum of Machærodonts appears in the Rosebud beds, with the dental formula reduced to that of *Hoplophoneus* and *Machærodus* but retaining the characteristic proportions of jaw and teeth of *Dinictis*. It may be provisionally referred to *Nimravus*,

but is a larger and more advanced species than any known from the John Day beds.

The discovery of a Chrysochlorid mole is a very interesting one. I have elsewhere[1] pointed out its importance in palæogeography.

The Rodents are well represented in this fauna, by a series of skulls and parts of skeletons. The John Day genus *Entoptychus* continues through the formation with species approaching *Thomomys* in some respects, but in others somewhat nearer the Heteromyidæ. The Oligocene genus *Steneofiber* branches out into a number of divergent species, which are almost generically distinct. From one of these the Upper Miocene (*Eucastor*) *Dipoides* may be descended; the others probably are not continued. The European *Steneofiber* is, according to Schlosser, directly ancestral to the modern beaver, through the Upper Miocene *Chalicomys*. But the structure of skull and skeleton is scarcely known in *Chalicomys*, and Schlosser's argument is as usual founded principally upon the structure of the teeth. His statement, however positively expressed, can only be accepted provisionally, since, as Peterson has shown, the Steneofibers of this country at least, were animals of rather specialized fossorial habits, and the trend of their evolution in America is certainly not in the direction of the modern beavers. It is quite possible, however, that from the Oligocene Steneofibers have descended *Castor* in Europe, *Dipoides* and *Mylagaulus* in America, the last through some form related to *Euhapsis*.

The Hares are represented in the Rosebud fauna by species which cannot be separated from the modern genus *Lepus*, although the tooth pattern is more primitive in many minute details. The feet are as modern as the teeth, and present no distinctions of generic importance although in many minutiæ they retain vestiges of a more primitive construction.

The Equidæ are represented in this fauna only by species of the Mesohippinæ (with short-crowned uncemented teeth, lateral toes typically reaching the ground, but no vestige left of the pollex). The genus *Parahippus* occurs in the upper beds, and in the lower beds are *Mesohippus* and a transitional form between the two. These forms do not appear to be directly ancestral to *Merychippus* and the other Protohippinæ, in which the vestigial pollex is retained, although it is lost even in the Middle Eocene *Orohippus*. The Protohippinæ are probably an immigrant group, appearing first in the Middle Miocene. The Mesohippinæ continue along with them through the Middle and Upper Miocene in the genera *Parahippus*, *Hypohippus*, and *Archæohippus*, to which the Rosebud species afford an excellent transitional series from *Mesohippus* and *Miohippus* of the Oligocene.

[1] 'Science,' *loc. cit.*

The *Parahippus* of the upper Rosebud has the lateral digits more reduced than in *Neohipparion*, and we may yet find species of this genus completely monodactyl, paralleling the direct line of descent of the modern horse, and more advanced in foot structure while more primitive in teeth.

Rhinoceroses are not common in the Rosebud beds on Porcupine Creek, only two skulls having been found. They have been provisionally referred to *Diceratherium*, with which they appeared in the field to agree. If this reference is confirmed, and no intermediate forms turn up later, we may conclude, as Osborn has already suggested, that the *Aphelops-Teleoceras* group of Rhinoceroses were of Old World origin and not derived from the rhinoceroses of the American Oligocene.

The Tapirs are indicated only by a single lower molar, which adds nothing to our knowledge of their development.

The Oligocene genus *Elotherium* persists into the Lower Rosebud. In the Upper Rosebud the true peccaries are represented by an intermediate stage between the Oligocene *Perchœrus* (*Thinohyus*) and the more specialized genera of the later Tertiary.

The camels are represented by two or more species, apparently of the genus *Miolabis*, as seen in the field, and not far from *M. transmontanus* of the Mascall beds in Oregon. They have short-crowned teeth, upper incisors unreduced, and separate metapodials, and differ chiefly in size from the John Day camels. In the Middle Miocene of the Plains the camels have long-crowned teeth; some have separate, others united metapodials, and the upper incisors 1 and 2 are generally present though often reduced in size. In the Upper Miocene the teeth are long-crowned, the upper incisors absent, the metapodials united.

Oreodonts are very abundant in the Rosebud. *Promerycochœrus* is very common in the lower beds, and there are various smaller Oreodonts with short-crowned teeth probably referable to *Mesoreodon* and *Eporeodon*. *Leptauchenia* is found only in the lower levels of the Lower Rosebud beds. In the Upper Rosebud *Promerycochœrus* is replaced by *Merycochœrus* and the smaller Oreodonts by *Merychyus*, a primitive species allied to *M. arenarum* Cope.

The smaller ruminants are represented in the Lower Rosebud by *Hypertragulus*, an advanced species as compared with the John Day or White River types; and odd teeth and jaw fragments indicate other small ruminants of this family. In the Upper Rosebud the Hypertragulidæ have disappeared and their place is taken by *Blastomeryx*, the most primitive of the Merycodontinæ. This is a true Pecoran and the earliest from this country. It has the characteristic form of the cannon bones of fore and hind foot, the distal metapodial keels extending over the superior surface of

the articulation, and various other distinctive features to which no approximation is made in any of the older American ruminants. It must be regarded therefore as a forerunner of the several immigrant types of the Middle Miocene already referred to.

Comparison with the Lower Miocene of Northwestern Nebraska.

The collections made for the Carnegie Museum by Hatcher and Peterson at the headwaters of the Niobrara River are chiefly or entirely of Lower Miocene age, as Peterson's recent studies have shown. The exact correlation of the several faunal levels with those of the Rosebud is not yet advisable. It is quite probable that many species will be found common to both regions, but as far as published results and comparison of prepared material have shown, the faunæ have less in common than one would expect, and perhaps represent somewhat different facies. The present indications are that they cover about the same geological time.

Comparisons with European Faunæ.

The three principal faunæ with which the Rosebud can be compared are:

[1] St. Gerand-le-Puy, ... Upper Oligocene
[2] Orleanais . . . . . Lower Miocene
[3] Sansan . . . . . Middle Miocene

These are the faunæ taken by Osborn as typical of these three Tertiary stages.

Close comparisons can be made in but few instances with any of the European faunæ, and for the most part we must depend upon the greater or less degree of approach to modern types for correlation. Where any close comparisons can be made, it usually means that a phylum developed in one region has extended its range to others, and we expect to find it more advanced in its original home than in its later range, and least advanced in the regions most remote from its place of origin.

1. St. Gerand.— Comparison with the St. Gerand fauna gives the following data:

The European Lagomyidæ correspond to the American Leporidæ, but *Titanomys* of St. Gerand is much more primitive than *Lepus* of the Upper Rosebud, corresponding in its stage of molar development to the earliest *Palæolagus* (*P. brachyodon, temnodon*) of the Lower White River.

Steneofiber viciacensis of St. Gerand is less specialized than the *Steneofiber* of the Lower Rosebud, corresponding more nearly with the John Day species in its stage of development.

Potamotherium, *Proailurus*, and *Amphicyon lemanensis* are comparatively modernized; *Plesictis*, *Amphictis*, "*Herpestes*" *lemanensis*, and *Palæogale mustelina*, are primitive survivals, related to the Phosphorite fauna, and equivalent in development to the White River and John Day carnivora, much more archaic than anything in the Rosebud. *Cephalogale* appears to be quite nearly related in dentition to *Cynodesmus thomsoni* (infra), judging from Filhol's figures of *C. brevirostris*.

Cœnotherium in the St. Gerand fauna takes the place of the American Hypertragulidæ, which are characteristic of the White River and John Day, although one or more species survived into the Lower Rosebud. *Hyotherium* compares with *Perchœrus* of the White River and *Thinohyus* of the John Day, but is decidedly more primitive than the Rosebud species referred to *Thinohyus*. *Dremotherium* of St. Gerand is a primitive stage of the Pecora which first appear in this country in the much more advanced *Blastomeryx* of the Upper Rosebud. An exact comparison, however, of *Dremotherium* and *Amphitragalus* with *Blastomeryx* is not practicable, the phylogeny of the Pecora being far from clear.[1]

From the above data it would appear that the St. Gerand fauna is on the whole decidedly more ancient than either of the Rosebud faunæ and more nearly equivalent to the John Day.

2. Orleanais.— The data for comparison with this formation are not very satisfactory. The carnivora and rodentia are of no especial value for the purpose, except *Chalicomys*, which may be compared with the specialized Steneofibers of the Rosebud as an equivalent but divergent outgrowth from the primitive Steneofibers of the Oligocene, and *Myolagus*, which is nearly as modernized as the Rosebud *Lepus*. Proboscidea first appear in the Orleanais beds while in America they first appear in the Deep River; as this group has been shown to be of African origin its earlier appearance in the European than American Miocene would be expected. On the other hand the Equidæ are more advanced in the Rosebud, *Parahippus* being a step beyond *Anchitherium*; and as this group appears to be of American origin, we should expect to find it more advanced in American formations than in their European equivalents. *Listriodon*, and *Sus palæochœrus* might be regarded as more modernized than the Rosebud peccary, *Hyotherium chœroides* hardly as much. *Teleoceras aurelianensis* compares with *Aphelops* of the Deep River (Pawnee Creek) formation and is probably a more advanced type than the Rosebud rhinoceroses.

[1] I am unable to accept Schlosser's view that the Pecora are in part (Sivatheriinæ Cephalophinæ, Gazellinæ) derived from the American Hypertragulidæ (including *Protoceras*) in part (Giraffinæ, Cervidæ, and the remaining Bovidæ) of European ancestry. Their characteristic and unique foot structure is not approached by any of the American Eocene or Oligocene ruminants but appears suddenly, and fully developed, in the Miocene of this country. It is very probable that the group is rather of Asiatic than European origin and its outlying members only are represented in the late Eocene and Oligocene of Europe so that the direct phylogeny is still unknown. But the group of Pecora appears to be a natural one and of Palæarctic origin.

Altogether the Orleanais fauna may be regarded as a near equivalent of the Rosebud, more advanced in groups of Old World origin, more primitive in groups of New World origin, but lacking in closely related types.

3. Sansan.— This fauna appears distinctly more modernized than the Rosebud, and compares fairly well with the Deep River and Pawnee Creek fauna. *Amphicyon* and the Chalicotheres attain much larger size, the rhinoceroses are larger and more advanced, *Palæomeryx* and allied genera appear, and all the more primitive ruminants have disappeared. In all these respects it is decidedly later than the Rosebud. The horses remain primitive and there is little opportunity for comparison in the rodents and most of the carnivora.

The above comparisons indicate that the Rosebud faunæ are later than the Upper Oligocene, and earlier than the Middle Miocene of the European standard. Their position is thereby fixed as Lower Miocene, the Lower and Upper Rosebud representing an earlier and a later stage.

Descriptions of New Species.

The only parts of the collection at present accessible for study are the Carnivora, Rodentia, Equidæ, and a few of the smaller Artiodactyla. The Equidæ, although fragmentary, afford some interesting data on the phylogeny of the family which will be presented by Professor Osborn in another contribution.

CARNIVORA.

Canidæ and Mustelidæ are well represented, but Felidæ appear to be rare, as only a single lower jaw was found by our party. Procyonidæ should also be included in this fauna, as the skeleton of *Phlaocyon* from the Martin Cañon beds in Colorado is from a horizon approximately equivalent. I have elsewhere shown the relationship of *Phlaocyon* to the modern *Procyon*, to which it appears to be approximately although not exactly ancestral, and it will appear in the course of the following descriptions that the nearest comparisons among modern Canidæ with those of the Oligocene and Miocene of this country, are to be found among the Neotropical and Oriental species. It is not clear whether this is the case among the Mustelidæ — the new genus *Megalictis*, described below, and probably also *Ælurocyon* Peterson, compare best with the Oriental and African genus *Mellivora*; but for the most part the modern Mustelidæ are a Holarctic group with few southern representatives and those closely allied to the typical forms, while the Oligocene and Miocene representatives of the family in America are mostly imperfectly known, primitive in dentition,

and their exact relationship to any surviving types has not been determined. The relationship to modern Neotropical and Oriental faunæ is equally apparent in other groups of the Middle Tertiary faunæ of the Western States, as the Tapirs, Peccaries, and Camels, and perhaps among the Deer. It is not true of the Rodentia, which seem to have either adapted themselves to changing environment without migration, or to have become extinct.

CANIDÆ.

The resemblance of the various species of upper Oligocene and Lower Miocene Canidæ to one or another of the species now inhabiting South America is a very significant fact. The nearest comparisons among modern dogs in details of structure of the teeth, as well as in proportions and structure of the skull are always to be found in South American or Oriental species rather than among the wolves, jackals, and true foxes which constitute the typical group of Canidæ. None of the John Day or Rosebud species are quite typical in dentition — all are more or less aberrant, and their peculiarities are paralleled by one or another of the various aberrant Canidæ of the Neotropical and Oriental regions. The dentition of *Nothocyon lemur* and *latidens* can best be compared with that of *Canis parvidens* or *urostictus*, of *N. gregorii, geismarianus* and *vulpinus* with *C. azaræ, magellanicus*, etc., of *Cynodesmus thomsoni* and *minor* with *C. cancrivorus*, etc., of the *Enhydrocyon-Temnocyon* group with *Icticyon* and *Cyon*. There are several aberrant types of modern Canidæ in the African continent (*Otocyon, Lycaon, Canis zerda*) but there is no suggestion among our Tertiary Canidæ of any especial relationship to these.

All the modern Canidæ are separated from the Middle Tertiary genera by the much larger brain and more specialized feet, and these features are about equally developed in the typical and aberrant groups. The amount of difference in these respects between the Oligocene or Lower Miocene genera and any recent dogs much exceeds the differences *inter se* among the two groups. But they are obviously characters of specialization and may be supposed to have proceeded at an equivalent rate in races already distinct in the Middle Tertiary. The Upper Miocene and Pliocene Canidæ which should exhibit intermediate stages, are very imperfectly known, and it seems premature to attempt any detailed phyletic connections, except in the very aberrant genera. *Cyon* and probably *Icticyon* are pretty clearly derivable from the John Day *Temnocyon*, the characters of skull and skeleton confirming those of the teeth. The more typical South American Canidæ cannot so safely be connected in detail, but in general may be said to be the nearest living representatives of the Middle Tertiary *Nothocyon*

and *Cynodesmus*. *Mesocyon* is slightly off the line in the direction of *Temnocyon* although much nearer to the typical group.

The accepted classification of the extinct Canidæ divides them into three subfamilies, Caninæ, Simocyoninæ, and Amphicyoninæ. The genera grouped under Simocyoninæ by von Zittel in his classic textbook do not, however, form a natural group. As Dr. J. C. Merriam has recently observed in his very discriminating and suggestive remarks upon the carnivora of the John Day "The continuance of their definite arrangement in one subfamily will serve only to cover up certain weak places in our phylogenies and ultimately to impede the progress of knowledge." In this opinion I entirely agree, and believe that the genera *Cephalogale, Simocyon, Oligobunis, Enhydrocyon,* and *Hyænocyon* are in no respect a natural group. *Oligobunis,* as is shown later in this paper, is probably a Musteline, and has no resemblance in either form or proportions of the teeth to the remaining genera. *Enhydrocyon* and *Hyænocyon* are closely related, probably not separable generically, and with Merriam's new genus *Philotrox* appear to be more nearly allied to *Temnocyon* and through this genus to *Cyon,* than to the typical Canidæ. *Cephalogale* appears to belong rather to the typical Canidæ, with basin talonids, well developed metaconids, conules present on the upper molars, etc. The only atypical characters, judging from Filhol's figures, appear to be the short robust skull, large subquadrate molars and crowded and slightly reduced premolars, characters seen in a less degree in *Cynodesmus,* especially *C. thomsoni* (infra). Dr. Schlosser regards the genus as ancestral to the Ursidæ, but even if this view were accepted, the genus is so close to the typical Oligocene Canidæ that it should be associated with them.[1]

The character of the molar heels appears to be a very constant feature among the Canidæ, and may be of prime value in the arrangement of the fossil genera if it proves to accord with the more important but less generally available characters of the basicranial region and of the feet. In nearly all the modern Canidæ the heel of the carnassial is composed of two equal cusps (hypoconid and entoconid) with a more or less clearly defined basin between. The trigonid of the second molar is also bicuspid and the heel basin-shaped. These features are shown in *Cynodesmus, Nothocyon, Ælurodon, Cynodon, Cynodictis, Cephalogale,* and various other extinct genera. In *Cyon* and *Icticyon, Lycaon, Temnocyon, Ischyrocyon, Enhydrocyon, Simocyon,* and less completely in *Daphænus, Amphicyon, Dino-*

[1] It appears to the writer to be obviously improper to separate two closely allied genera or species because they are destined to give rise in the future to two distinct families, in the opinion of the investigator. So far as nomenclature and classification are based upon the facts of structural resemblance or difference, they are permanent, but the attempt to make families, genera, or species correspond with hypothetical phyla is not simply misleading but destructive of any approach to uniformity or permanency of arrangement.

cyon, and *Mesocyon,* the carnassial heel and the trigonid and heel of m_2 are each composed of a single trenchant ridge, the hypoconids being crested and submedian, the entoconids vestigial or absent, and the metaconid reduced or absent upon m_2, and upon m_1 as well in the first five genera. The upper molars show corresponding differences. In the first group the conules and inner shelf are well developed giving a comparatively flat tuberculate crushing surface. In the second group the conules and inner shelf are mostly reduced or absent, giving a deeply concave crushing surface corresponding to the convexity in the lower molars.

Whatever the value of these characters of the molars may prove to be they do not give an adequate basis for subfamily division of the Canidæ, nor does it appear to the writer that there are any such well marked distinctions among them at any epoch of their evolution as to warrant subfamily division. On the contrary they appear to be a rather homogeneous group, and the diversity among them is by no means comparable to that which exists among the Mustelidæ. It is possible to disentangle and trace out several different phyla more or less accurately, but to give these phyla a subfamily distinction would be misleading.

Nothocyon *Matthew.*

The more typical Canidæ of the John Day fall into two closely allied genera, *Mesocyon* (=*Hypotemnodon,* or "*Temnocyon*" *coryphæus* and *josephi*) and *Nothocyon* ("*Galecynus*" *geismarianus, lemur* and *latidens*). The former genus includes larger forms with the sectorial dentition better developed and tubercular dentition smaller; the latter, smaller species with reduced sectorial and larger tubercular dentition, large eyes and large bullæ. In both genera the shear of the carnassials is largely transverse, although somewhat less so than in the White River Canidæ.

The next stage in the evolution of typical Canidæ is shown in *Cynodesmus* of the Fort Logan beds of Montana, in which the dentition approximates that of the microdont forms of modern Canidæ, while the brain and, as we are now able to add, the feet, retain more nearly the primitive structure of the Oligocene dogs. The carnassial shear has become nearly anteroposterior and the subordinate transverse shear has disappeared.

The typical Canidæ of the Rosebud beds are intermediate between the John Day genera and *Cynodesmus,* but those of the Lower Rosebud are nearer to *Nothocyon* and *Mesocyon,* and those of the upper beds to *Cynodesmus,* and are referred accordingly.

Nothocyon gregorii sp. nov.

The type (No. 12879) is a skull with parts of the jaws and fragments of limb bones from the lower beds, found by Mr. W. K. Gregory of the Museum Expedition of 1906. It is a little smaller than the skull figured by Cope (Tert. Vert., pl. LXX, fig. 2) as *Galecynus geismarianus*; the orbits are proportionately larger and closer together, the postorbital processes stronger, there is hardly any sagittal crest, the postorbital constriction is

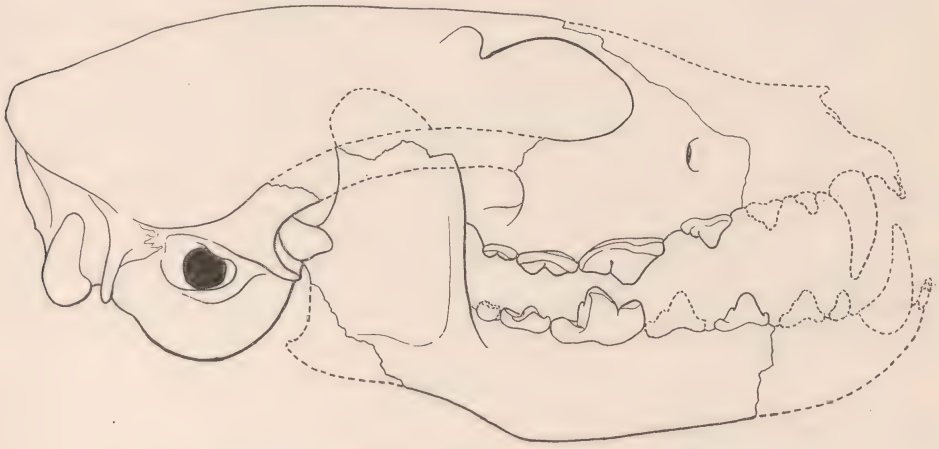


Fig. 1. *Nothocyon gregorii.* Skull, natural size. Type specimen.

narrower, the bullæ are larger and closer together, the paroccipital process more closely united with them and its tip directed downward instead of partly backward as in the John Day species. The premolars are smaller, the upper carnassial has a more longitudinal shear and its antero-external angle is less rounded. The lower teeth show corresponding differences so far as they are preserved.

Nothocyon vulpinus sp. nov.

Type, a lower jaw with parts of upper jaw, fore and hind limb bones and other fragments, No. 12883, from the Lower Rosebud beds. The species is a little larger than *N. gregorii*, the jaw longer and more slender, premolars larger, considerably spaced. The dental formula is $I\frac{3}{3}$, $C\frac{1}{1}$, $P\frac{4}{4}$, $M\frac{2}{3}$. Third lower molar two-rooted. The carnassial is larger and more elongate than in *N. geismarianus*, the premolars spaced, the molars more compressed. The limb bones compare closely in size and proportions with *N. geismarianus* but show a somewhat greater degree of modernization throughout. The humerus is long and slender, supinator and deltoid ridges low, entepicondylar foramen present. The ulna, including the olecranon, is as long as the humerus. The radial shaft is stouter than the ulnar shaft.

towards the distal end, but they have about the same stoutness in the proximal half. The head of the radius is round-oval, and its distal end has lost

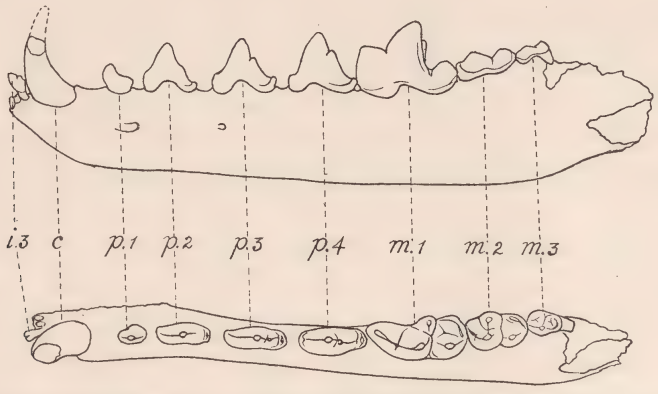


Fig. 2. *Nothocyon vulpinus*, lower jaw, external and superior views, natural size. Type specimen.

the triangular outline characteristic of early carnivora. The fibular shaft is still moderately strong. The astragalus has a rather deep, narrow trochlea and no astragalar foramen.

Measurements.	mm.
Length of lower dentition	60.
" " premolar "	27.5
" " true molars	22.4
Diameters of m_1, anteroposterior	11.8
" " " transverse	4.8
Diameter of m_2, anteroposterior 6.9; transverse	4.
Humerus, length	98.3
" diameter of head	22.8
" " " distal end	21.7
Ulna, length	100.
" diameter of olecranon	12.5
Radius, length	82.
" diameter of head	9.3
" diameter of distal end (transverse)	15.
Fibula, diameter of shaft	3.
Tibia " " "	8.
Astragalus, length	18.2
" width of trochlea	6.8
Calcaneum, length	28.5

Nothocyon, sp. div. innom.

A lower jaw, and parts of the upper and lower jaws of a second individual and probably other fragmentary specimens indicate a third species about as large as *N. gregorii* but with longer jaw, larger sectorials and

smaller tubercular teeth. A fourth species, approaching *N. latidens* in size and characters, is indicated by part of a lower jaw with the carnassial preserved. It seems undesirable to name these species until more complete specimens are obtained.

Mesocyon robustus sp. nov.

Type No. 12884, lower jaws with complete dentition, from the Lower Rosebud. A less complete jaw is referred to the species.

The species is about the size of *M. josephi* Cope from the John Day, smaller than *M. coryphæus*. The premolar region is robust and deep,

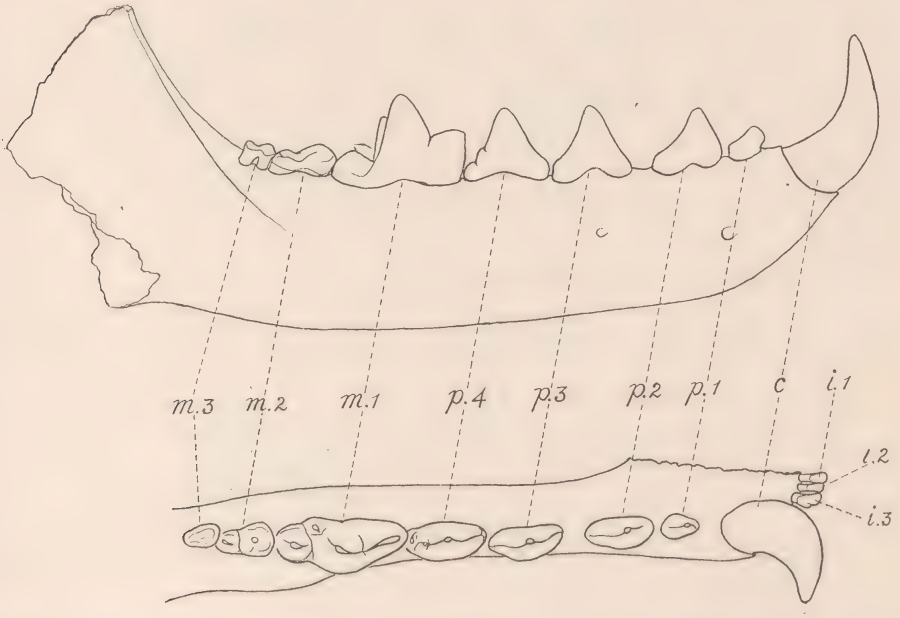


Fig. 3. *Mesocyon robustus*, lower jaw, external and superior views, natural size. Type specimen.

the premolars of moderate size and spaced. The heel of the sectorial tooth is trenchant with slight entoconid ridge; the tubercular teeth are also partly trenchant instead of fully tubercular as in *M. coryphæus*. The third molar is present on one side of the jaw, but absent on the other, indicating that this tooth is variable. The canines are much more robust than in *Nothocyon*.

Measurements.	mm.
Length of lower dentition	72.7
" " premolar "	33.5
" " true molars 1–3	24.2
Diameters of m_1, anteroposterior 14.9; transverse	6.2
" " m_2 " 6.2; "	4.4
Depth of jaw beneath m_1	6.

Cynodesmus *Scott.*

From Prof. Scott's figures and description, the type species of this genus is somewhat more modernized in dentition than the species here referred to it. They agree with it, however, in having the jaw somewhat reduced in length and the rather small premolars closely set, while in *Nothocyon* and *Mesocyon* they are spaced and the jaw is slender and of less depth. The larger and more predaceous dogs at this stage of evolution are represented by the so-called *"Canis" brachypus* Cope of the Laramie Peak beds. This species is in some respects more primitive than *Cynodesmus thoöides*, notably in the more transverse carnassial shear and backwardly directed paroccipital process; but the feet are somewhat more modernized than in the Rosebud species referred to Scott's genus; the metapodials are more compressed and elongate and the retractility of the claws has been lost. The brain-case is evidently of small capacity, and although no trace of the structure of the brain is preserved we may infer from the size that it was not more advanced.

Cynodesmus thomsoni sp. nov.

The type is a finely preserved skull and jaws, with the fore part of the

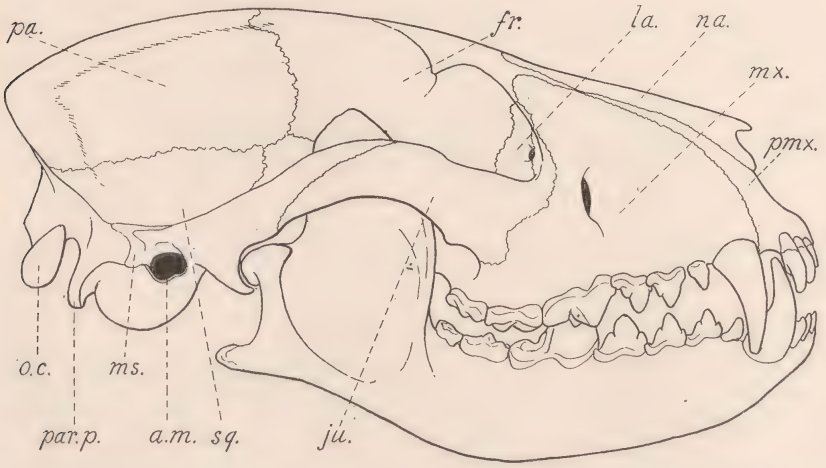


Fig. 4. *Cynodesmus thomsoni.* Side view of skull and jaws, two-thirds natural size. Type specimen. *a. m.*, auditory meatus; *fr.*, frontal bone; *ju.*, jugal; *la.*, lachrymal bone with foramen; *ms.*, mastoid process; *mx*, maxillary; *na.*, nasal; *o. c.* occipital condyle; *pa.*, parietal bone; *par. p.*, paroccipital process; *pmx.*, premaxilla; *sq.*, squamosal bone.

skeleton, from the Upper Rosebud beds, found by Albert Thomson of the Museum party of 1906.

The species is smaller than *C. thoöides* and of a less predaceous type, with shorter muzzle, smaller sectorial and relatively larger tubercular teeth

The premolars and carnassials are about one fourth smaller, while the tubercular teeth are of nearly the same size as in the type. The sagittal crest varies from an eighth to a quarter of an inch in height and the occipital crest is correspondingly developed. The bullæ are of moderate size, and the paroccipital much closer to them than in *C. thoöides*, projecting downward at the tip. The direction of the carnassial shear agrees nearly with the type species.

Among modern Canidæ, *Canis cancrivorus* affords the nearest comparison with *Cynodesmus thomsoni*. The size and general proportions of the skull are much the same, except for the shorter and heavier muzzle, larger teeth and more powerful jaws of *C. thomsoni*, and its very much smaller brain-case with consequent development of sagittal and occipital crests. The postorbital constriction is hardly more than half as wide and the posterior nares narrow and deep. The zygomata and postglenoid processes

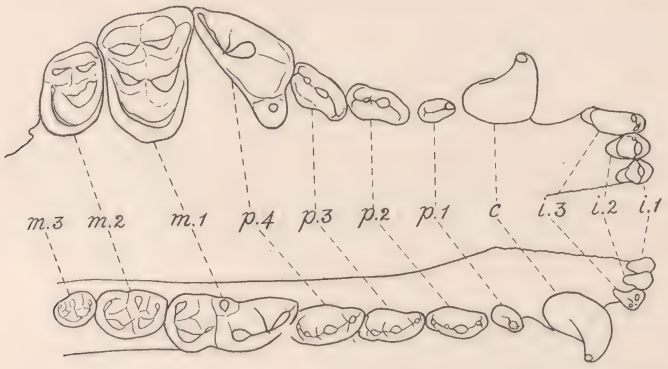


Fig. 5. *Cynodesmus thomsoni*, crown view of upper and lower teeth, natural size. Type specimen.

are much heavier, the pterygoids larger with hamular processes much more prominent, the jaw deeper with much broader coronoid processes, wider condyles, and masseteric fossa correspondingly wide and deep. The bullæ are slightly larger and the basisphenoid not so wide, but otherwise the basicranial bones and foramina are very like those in the modern species. I^3 is larger, with strong lateral cusp; the canines are longer and more robust; the premolars somewhat larger, more robust, and close-set, the accessory cusps well developed; the carnassials are slightly longer and much more robust, the shear somewhat more transverse; the inner half of the upper molars and the heels of the lower molars are much broader.

The fore foot is widely different from that of modern Canidæ, intermediate between *Cynodesmus brachypus* and the Oligocene Canidæ. The carpus has not the compact structure and relative height of the modern dogs, but in composition and proportions resembles the primitive type of *Cynodictis*. The metacarpals are not at all appressed and but little elongate;

Mc. I is somewhat more reduced, but not more than in the modern *Mustela pennanti,* much less than in *Viverra,* and far less than in any modern Canidæ. The phalanges are short, as in the dogs; in most Mustelidæ and Viverridæ they are relatively long. The penultimate phalanx shows the asymmetric excavated upper surface of the shaft indicating that the claws were partly retractile, but somewhat less so than in the Oligocene dogs. The ungual is narrow and compressed with a slight hood at the base. In *Cynodesmus brachypus* the retractility of the claws has been lost, and the metacarpals are longer and more appressed, though far less so than in *Canis;* the pollex is not known.

A fragmentary skull with parts of the lower jaw (No. 12875) indicates a smaller variety or distinct species nearly related to *C. thomsoni,* and other fragmentary specimens are referred here provisionally. In one of them (No. 12876) the hind leg with part of the foot is preserved and shows a comparatively strong fibula, the shaft scarcely if at all reduced beyond what is seen in *Daphœnus* and *Cynodictis.* The first metatarsal indicates a complete digit fairly well developed but considerably smaller than in the White River dogs.

The construction and proportions of fore and hind feet in this species nearly resemble those of *Phlaocyon* as figured by Matthew[1] but the animal was of larger size and the limbs more elongate.

Measurements.	mm.
Length of skull	132.7
Width " " at zygomata	81.
Width of postorbital constriction	18.4
" " brain-case	46.
Length of upper dentition (left side)	68.5
" " lower "	67.2
" " upper premolars	31.
" " upper true molars	16.
" " lower premolars	26.8
" " " true molars	26.9
Diameter of p_4, anteroposterior 13; transverse	8.
" " m^1 " 10.5; "	13.7
" " m^2 " 5; "	6.4
" " m_1 " 14.5; "	6.8
" " m_2 " 7.5; "	5.5
Length of jaw, incisors to condyles, 104.5; depth beneath m_1	17.9
Width of proximal end of metacarpus	24.
Length of first metacarpal	17.
" " fifth "	30.
" " first phalanx	18.
" " second "	10.
" " third "	12.

[1] Mem. Amer. Mus. Nat. Hist., Vol. I, pl. vii, p.

Cynodesmus minor sp. nov.

A second smaller species from the Upper Rosebud is represented by the upper and lower jaws (No. 12877, type), by a separate lower jaw (No. 12878), and other fragmentary specimens. It is about two thirds (lineal) as large as *C. thomsoni*, and has a shorter carnassial with larger internal cusp, relatively larger tubercular teeth, especially m^2, and the lower premolars are longer and not so high.

Measurements of type. mm.

Diameters of p^4,	anteroposterior	8.7;	transverse	. . . . .	5.7
" " m^1	"	7;	"	. . . . .	9.2
" " m^2	"	5;	"	. . . . .	8.
" " m_1	"	9.6;	"	. . . . .	4.1
" " p_4	"	7.	"	. . . . .	3.2
" " p_3	"	6;	"	. . . . .	2.6
" " p_2	"	4.9;	"	. . . . .	2.

Enhydrocyon *Cope.*

The characters of this genus and of *Hyænocyon* have been much confused by careless diagnosis and improper transference of types. The following corrections are necessary in order to clear up the status of the two genera.

1. The type of *Enhydrocyon stenocephalus*, No. 1 of Cope's *original* description,[1] Am. Mus. No. 6902, consists of fragments of upper and lower jaws with unworn teeth, the premolars not completely protruded. A finely preserved skull with teeth much worn and defective, No. 6901, was used as paratype. The type specimen shows that there were probably but three upper premolars, that m_2 was present, the heel of m_1 and trigonid of m_2 trenchant. The paratype has a tooth formula of I^3, C^1, P^3, M^2. The teeth in the type appear to be considerably larger and the premolars, more obliquely set and crowded than in the paratype; this difference however may be individual or due to age.

2. The type of *Hyænocyon* is *Enhydrocyon basilatus* Cope,[2] based upon a lower jaw, No. 6904. Cope subsequently referred to it an upper jaw, No. 6905, and defined the genus[3] on these two specimens as having a dentition of $P\frac{3}{4}$, $M\frac{1}{1}$. This was corrected afterwards[4] to $P\frac{3}{3}$, $M\frac{1}{1}$, and still later the upper jaw was separated as the type of *Hyænocyon sectorius*.[5]

[1] Bull. U. S. G. S. Terrs., Vol. V, No. 1, p. 56, Feb. 28, 1879.
[2] *Loc. cit.* p. 57.
[3] Palæont. Bull., No. 31, p. 3, Dec. 24, 1879.
[4] Amer. Nat., 1881, p. 497, May 19.
[5] Amer. Nat., 1882, p. 246.

3. By clearing away the matrix from the type of *H. sectorius* it appears that Cope was mistaken in supposing m^2 to be absent, as the alveoli of its roots are certainly present. It has therefore the same dental formula as *Enhydrocyon,* to which it is in all other respects closely allied. In the lower jaw, type of *H. basilatus,* m_2 appears to be absent, at least on one side, but I suspect from the appearance of the specimen that this is a mere abnormality. The validity of the genus *Hyænocyon* is therefore very questionable, as there are no material differences in the form of the teeth to distinguish it generically from *Enhydrocyon.*

The above mentioned specimens from the John Day constitute all that has hitherto been known of this aberrant group of Canidæ.

Enhydrocyon crassidens sp. nov.

The type, No. 12886, consists of a complete skull and jaws with a considerable part of the skeleton, found by Mr. Thomson in the Lower Rose-

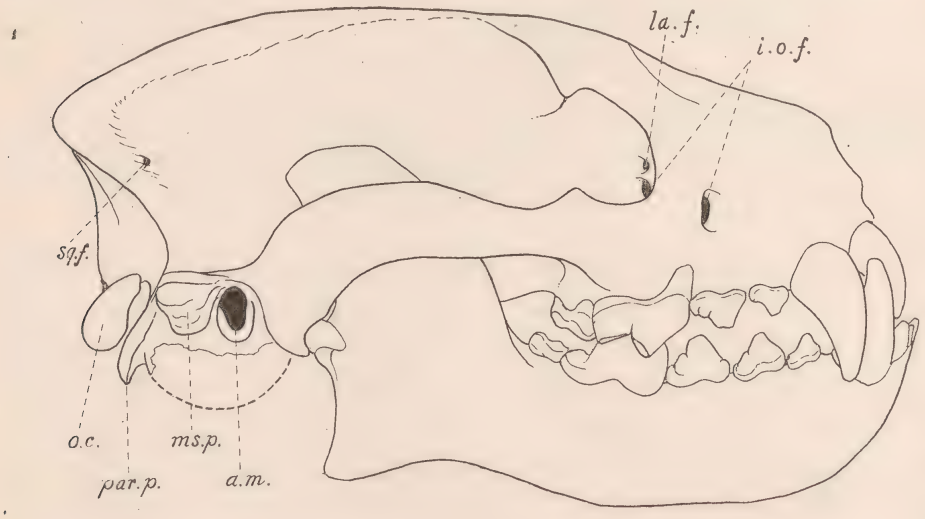


Fig. 6. *Enhydrocyon crassidens,* side view of skull and jaws, one half natural size. Type specimen, *a. m.*, auditory meatus; *la. f.*, lachrymal foramen; *i. o. f.*, infraorbital foramen; *ms. p.*, mastoid process; *o. c.*, occipital condyle; *par. p.*, paroccipital process; *sq. f.*, postparietal foramen.

bud bed. The species is somewhat larger than *E. stenocephalus,* the premolars simpler, the molar heel more reduced, and $m\frac{2}{2}$ smaller. The skull is a little more robust throughout, the brain-case considerably larger. The second upper molar is minute on one side, absent on the other; m_2 is small but not so much reduced as the corresponding upper tooth. The size is about the same as in *E.* (*Hyænocyon*) *sectorius,* the m^2 more reduced, p^3 with broader heel but less robust protocone, and p^2 set obliquely but in the opposite direction from the corresponding tooth in *sectorius,* its anterior end

lying inside instead of outside the canine. The Rosebud species is smaller and less robust than *E.* (*Hyænocyon*) *basilatus*, and the anterior premolars are less massive. The fragmentary nature of the types of the John Day species precludes any further comparison, but *E. crassidens* is quite clearly distinct from the referred skull of *E. stenocephalus* and more advanced in several respects.

The basicranial region agrees with that of *E. stenocephalus*. It is of moderate width; the bullæ are large, longitudinally oval; the auditory meatus is open, without ossified tube, the septum of the bulla little developed. The condylar foramen lies close behind the posterior lacerate foramen, in front of the crest connecting the base of the paroccipital process with the condyle. The carotid canal is not clearly recognizable. The

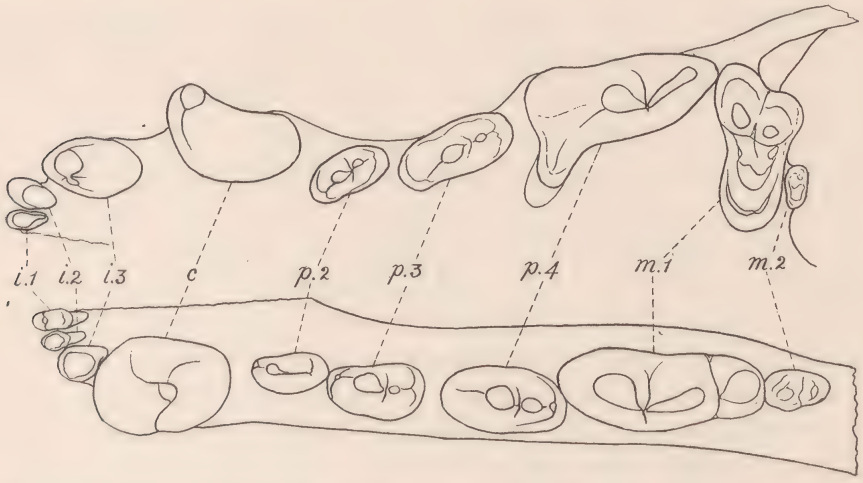


Fig. 7. *Enhydrocyon crassidens*, crown views of upper and lower teeth, natural size. Type specimen.

foramen lacerum medius is large, and the foramen ovale lies close outside of it. The postglenoid foramen is of moderate size. The alisphenoid canal is moderately long. The paroccipital process is close to the bulla at the base, and projects beyond it backward and downward in a rather long trihedral spine. The mastoid processes are well defined but not very large, and project moderately. The parts of the skeleton preserved are the first eight vertebræ, pelvis, fore and hind limb bones, astragalus and calcaneum.

The cervical vertebræ indicate a rather short neck, comparing rather with *Daphænus* in length than with any modern Canidæ. The fore limb bones are as large as in *D. vetus*, but the hind limb bones are considerably shorter and smaller. The deltoid crest of the humerus and the lower extremity of the ulna are more reduced, the head of the radius reduced on

the side next the ulnar facet. The shaft of the femur is straighter and more rounded in section; the patellar trochlea is very peculiar, short, rather wide and shallow, and almost distal in its position, while the condyles face inferiorly instead of distal-inferior. This peculiar conformation may be in part due to a vertical crushing of the bone, but not wholly so. It is paralleled to some extent in the hyænas, also in connection with small hind limbs and large fore limbs, and may indicate a similar pose of the skeleton. The tibia is much shorter than in *Daphænus*, cnemial crest more oblique and relatively higher. The astragalus is much more modernized than in *Daphænus*, the inner crest much more built out, higher and sharper, and there is no trace of the astragalar foramen, which is present although vestigial in *Daphænus*. The calcanear heel is considerably reduced in length.

The characters of the skeleton confirm Professor Cope's view of the affinities of *Enhydrocyon*, derived from study of the teeth and skull, but not his suggestion of aquatic habitat. It is an aberrant type of the Canidæ without marked relationship to any other family. Its nearest relative among the Canidæ is probably *Temnocyon* of the John Day, which has also the heel of m_1 and trigonid and heel of m_2 trenchant instead of basin shaped, upper molars without intermediate cusps and deeply concave transversely, and relatively small $m\frac{2}{2}$. But in *Temnocyon* the premolars are large and compressed, in *Enhydrocyon* they are small and robust and $p\frac{1}{1}$ absent. The modern genera *Cyon* and *Icticyon* are probably representatives of this group of Canidæ but derivable from *Temnocyon*. *Enhydrocyon* is an extinct branch. The group is connected with the typical Canidæ by such types as *Mesocyon*. All these and perhaps also some of the so-called Amphicyons of this country may be derived in a general way from *Daphænus* of the White River, more nearly than from *Cynodictis*. The more typical group of dogs, on the other hand, leading through *Nothocyon* and *Cynodesmus* into the modern *Canis*, *Vulpes*, etc., may preferably be derived from *Cynodictis*.

Such derivations are at the best approximate, and a more extended knowledge of the fossil Canidæ, may, and probably will, show the way to a closer approximation to the true phylogeny than can now be made

Measurements of Type. mm.

Length of skull, incisors to condyles	181.
Breadth of skull across zygomatic arches	110.
Width of postorbital constriction	28.
Height of occiput	54.
Width of palate and teeth	58.
" " condyles	28.
Length of upper dentition (left side)	89.

	mm.
Width of six incisors	25.
Diameters of canine, anteroposterior 13.2; transverse	9.2
" " p_2 " 9.6; "	6.3
" " p_3 " 14; "	6.8
" " p_4 " 22.2; "	13.
" " m_1 " 10.5; "	17.
" " m_2 " 3; "	4.5
Length of lower jaw, incisors to condyles	139.
" " " dentition (left side)	88.
Diameters of canine, anteroposterior 12; transverse	10.5
" " p_2 " 8; "	5.5
" " p_3 " 10.2; "	6.5
" " p_4 " 13.6; "	7.8
" " m_1 " 23; "	9.5
" " m_2 " 7.6; "	5.3
Depth of jaw beneath m_1	22.5
Length of humerus 153; diam. of distal end	38.5
" " radius 114; " " " "	25.
" " femur 143; " " " "	38.
" " tibia 139; " " " "	23.
Length of astragalus 30.; width of trochlea	13.

Mustelidæ.

Oligobunis *Cope.*

Cope described this genus as an aberrant member of the Canidæ, ancestral to *Icticyon,* and this reference has not hitherto been questioned. A re-examination of the type of *O. crassivultus* leads me to believe that it is more nearly related to the primitive Mustelidæ of the Oligocene and Miocene and should be transferred to that family. The type, Am. Mus. No. 6903, consists of the lower jaws and anterior part of the skull, from the John Day formation, and the principal diagnostic characters are as follows:

Dental formula, $I\frac{3}{3}$, $C\frac{1}{1}$, $P\frac{4-3}{4}$, $M\frac{2}{2}$. The jaws and muzzle are short and heavy and their general proportions rather musteloid than cynoid, the muzzle lacking the constriction in front of the carnassials common to most of the Canidæ, especially the early members. The canines are short and stout, the premolars rather small, massive, and simple, without accessory cusps except on $p\frac{3}{4}$. The antero-internal cusp of p^4 is well developed and, as in the later Mustelidæ, but to a less degree, constricted off from the rest of the tooth. M^1 is reduced antero-posteriorly and much extended transversely, the paracone nearly median, metacone vestigial and parastyle much extended, protocone compressed, and, as in all primitive Mustelines, it lacks the broad flange characteristic of the modern Mustelidæ. M^2 is very

small, transversely oval and lies behind the inner part of m^1 [the tooth was covered by matrix at the time of Prof. Cope's description and supposed by him to be absent.] The lower carnassial has a well developed metaconid and rather large heel with external crested hypoconid and broad slightly concave inner slope without entoconid. This form of heel is characteristic of most Mustelidæ; *Amphicyon* shows the nearest approach to it among the Canidæ with which I am acquainted, but in this genus the entoconid is developed as a low crest. M_2 is small, oval, tubercular, with low protoconid, metaconid and hypoconid of about equal height and somewhat marginal position. [Cope incorrectly described this tooth as composed of two trenchant cusps one behind the other, as in *Temnocyon*]. As in other primitive Mustelidæ the carnassial blades are separated by a distinct notch and the inner part of the upper tubercular lacks the broad flange found in all modern members of the family. The basicranial region is unknown but probably it would, as in *Bunælurus, Plesictis, Amphictis,* etc., show a large inflated bulla.

Oligobunis lepidus sp. nov.

This species is much smaller than the type, and the teeth and jaws much less massive. But the form and cusp composition of the teeth, and proportions of jaws and muzzle are otherwise very similar to the John Day species, although somewhat more advanced in the direction of modern Mustelidæ. The premolars are more characteristically musteloid, short, high, simple, and close set. The inner cusp of p^4 is somewhat larger and more clearly separated from the rest of the tooth. M_2 is somewhat smaller and of more oval shape, its three cusps more marginal, and the vestiges of its primitive tuberculo-sectorial form more completely obliterated. The sectorial blades of the carnassial are separated by a notch, and there is no flange on the protocone of m^1.

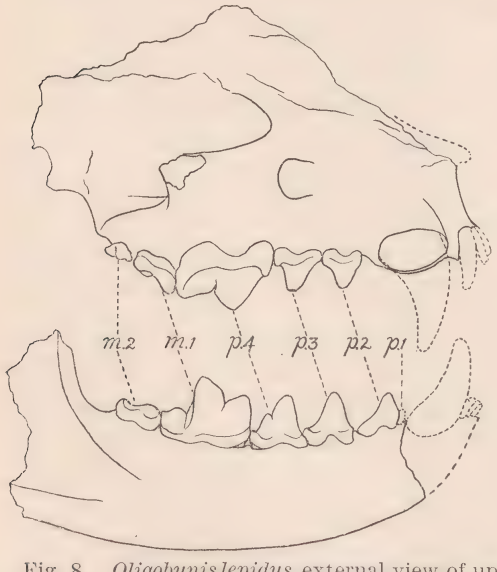


Fig. 8. *Oligobunis lepidus*, external view of upper and lower jaws, natural size. Upper jaw, No. 12866; lower jaw, No. 12867.

The type, No. 12865, is a damaged anterior part of the skull with lower jaw. A second specimen, No. 12866, shows the upper molars, which are

not preserved on the type. This specimen appears to be a distinct variety or species, the teeth being more robust throughout, the skull larger and wider and p^1 absent. A lower jaw, No. 12867, is referable to this more robust form, and shows corresponding differences in the teeth, p_1 being very minute. Another lower jaw, No. 12868, agrees with the type except for its larger size. In the absence of more material for comparison I do not think it advisable to distinguish these as separate species.

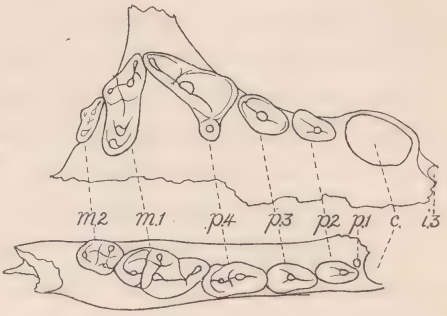


Fig. 9. *Oligobunis lepidus*, crown views of upper and lower teeth, natural size. Upper teeth, No. 12866; lower teeth, No. 12867.

Measurements.

	12865 Type	12866 var. *robustior*	12867	12868
Length of upper dentition (i^{1-2} and m^2 estimated)	36.			
Length of upper dentition exclusive of incisors		37.3		
Length of upper premolars	20.3	23.3		
Transverse diameter of lateral incisor	2.5			
Height of crown " " "	4.7			
Anteroposterior diameter of canine alveolus	5.4	7.7		
" " " p^2	4.0	5.		
" " " p^3	5.0	6.2		
" " " p^4	9.3	11.1		
Transverse " " p^4	6.8	7.3		
Anteroposterior " " m^1		5.0		
Transverse " " m^1		11.0		
Anteroposterior " " m^2		2.3		
Transverse " " m^2		5.		
Length of lower teeth, premolars and molars	30.4		31.4	32.
Length of lower premolars	16.9		17.3	18.3
" " " molars	13.9		14.9	14.5
Anteroposterior diameter of p_1	2.3			2.3
" " " p_2			4.9	4.2
" " " p_3			6.0	5.4
" " " p_4	5.7		6.5	6.2
" " " m_1	8.7		10.1	9.9
Transverse " " m_1	4.6		5.0	5.0
Anteroposterior " " m_2	5.0		5.2	4.8
Transverse " " m_2	3.7		4.0	3.7
Depth of jaw beneath m_1	10.0		12.0	11.0

Megalictis gen. nov.

This name is given to a very large musteline allied to *Mellivora* and *Gulo* but retaining many characters of the primitive Mustelidæ in greater or less degree.

Teeth transitional between *Oligobunis* and *Gulo* or *Mellivora*. Molars $\frac{2}{2}$, the second molar much reduced, oval and flat-topped. Antero-internal cusp of p^4 strong and well separated. M^1 extended transversely, the inner shelf moderately developed, less than in any modern Mustelidæ, more than in any of the Oligocene genera. M_1 without metaconid.

Skull short, wide, massive, extremely high in frontal region, zygomatic arch stout, sagittal and occipital crests heavy and rather high, occipital region low and wide, basicranial region broad, bullæ small, inflated, flat-

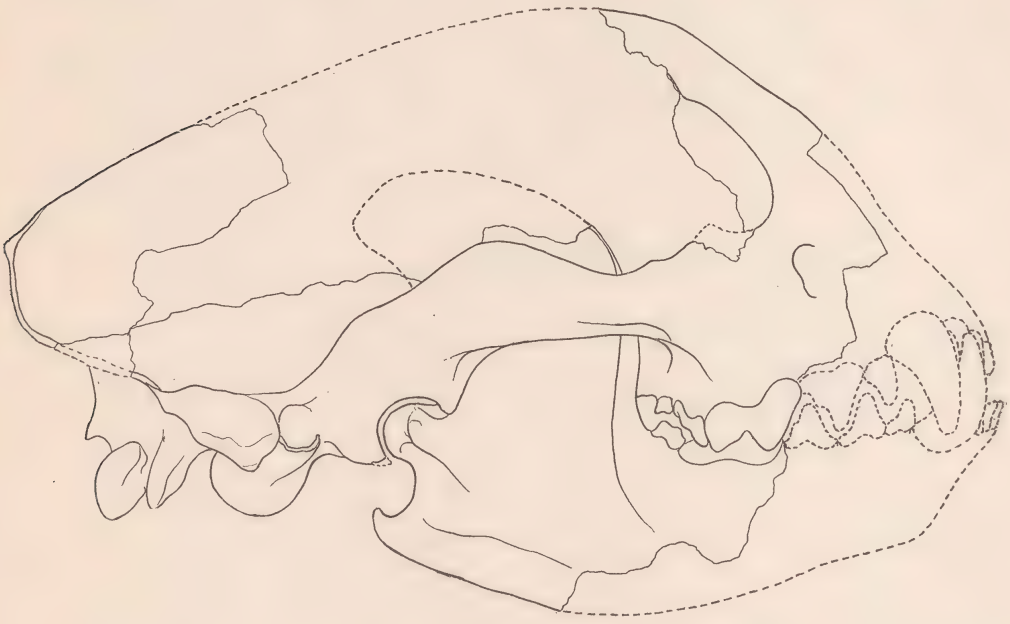


Fig. 10. *Megalictis ferox*, outline restoration of skull and jaws, side view, one half natural size. The full lines show the parts preserved in the type specimen.

tened marginally, auditory meatus long, flattened tubular. Mastoid processes stout, projecting laterally, paroccipital processes short, stout, spatulate, projecting backwards and partly downwards, well separated from bulla. Lower jaw short, deep, with wide condyles and broad coronoid process.

Ribs long, not flattened, lumbar vertebræ relatively short and small, caudals indicating a long and powerful tail. Limbs short and stout, feet plantigrade, short and spreading, five-toed, the pollex somewhat and hallux considerably reduced, phalanges short, claws large, non-retractile, little curved and not compressed, hooded at the base.

The above characters indicate an animal which may best be described as a gigantic wolverene, equalling a jaguar or a black bear in size, but in

proportions more like the ratel. The extremely high frontal region gives a peculiar aspect to the skull, suggesting *Cynœlurus*. The limbs and feet are decidedly shorter than in the wolverene, somewhat longer than in the ratel. The single claw-phalanx known indicates some degree of fossorial specialization, less than in the ratel, more than in the wolverene. The teeth indicate an animal fully as predaceous as the wolverene but the skeleton points to more fossorial habits.

Megalictis ferox sp. nov.

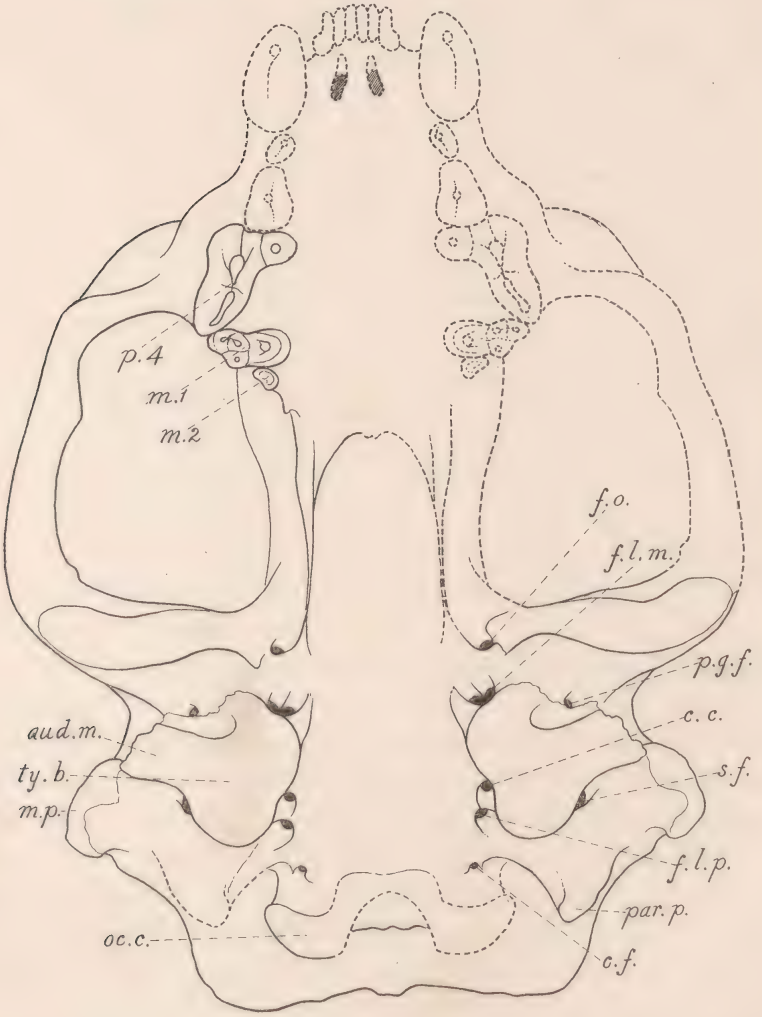


Fig. 11. *Megalictis ferox*, skull, inferior view, one half natural size. Type specimen. *Aud. m.*, auditory meatus; *c. c.*, carotid canal; *c. f.*, condylar foramen; *f. l. m.*, foramen lacerum medius; *f. l. p.*, foramen lacerum posterius; *f. o.*, foramen ovale; *m. p.*, mastoid process; *par. p.*, paroccipital process; *p. g. f.*, postglenoid foramen; *s. f.*, stylomastoid foramen; *ty. b.*, tympanic bulla.

The type, No. 12880, is a fragmentary skull and jaw, with parts of the fore limb and foot bones. A second specimen, No. 12881, includes limb and foot bones, ribs, and vertebræ. Both are from the Upper Rosebud beds and agree exactly in size and in the corresponding parts of limb and foot bones preserved. Between the two we are able to obtain a fair idea of the principal characters of the skeleton.

The more important features have already been given under the generic description. The skull has to an exaggerated degree the characteristic broad form, with short wide arches, short muzzle, broad basicranial region, seen in the large Mustelidæ, and differs from the comparatively narrow elongate skull of *Amphicyon* and the Canidæ. The form and position of the mastoid and paroccipital processes, and the arrangement of the basicranial foramina are also Mustelid, and the bulla shows in an incipient stage the flattening characteristic of this family. The large size of the animal and its comparatively small brain capacity cause the sagittal and occipital crests to be much more developed than in modern mustelines, more as in *Amphicyon*. The jaws and teeth anterior to the carnassials are unfortunately not preserved except for the root of p^4, and a part of the canine alveolus, but the contour of the facial bones enables us to restore the outlines with a fair degree of accuracy. The skull when found was in fragments more or less displaced but well preserved and uncrushed. The fragments were pieced together by Mr. Thomson and the writer with especial care, and the remarkable height of the frontal region and other peculiar characters cannot be ascribed to error in the preparation.

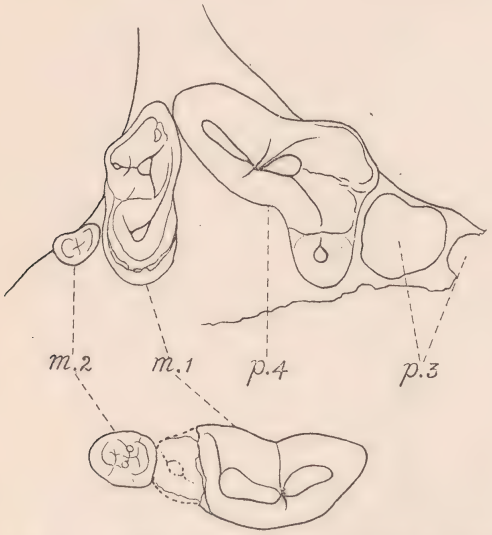


Fig. 12. *Megalictis ferox*, crown views of upper and lower teeth, natural size. Type specimen.

The bullæ are intermediate between the simple inflated cynoid type of the Oligocene Mustelidæ and the flattened form characteristic of most modern members of the family. They are flattened at the borders and the auditory meatus is long and partly flattened. *Taxidea* displays a somewhat similar intermediate condition. The alisphenoid canal is absent. The foramen ovale lies close to the inner margin of the glenoid articulation. The carotid canal is large and situated close in front of the posterior lacerate

foramen. The condylar foramen is posterior in position, at some distance behind the foramen lacerum posterius. The postglenoid foramen is of moderate size. The primitive form and position of the paroccipital processes is equally characteristic of the family to which *Megalictis* belongs. In the Canidæ they become slender, directed downward and closely approximate to the bulla; in the Viverridæ and Felidæ they become thin flat plates enveloping the back of the bulla. The stout, widely separated, projecting mastoid processes are as in the larger Mustelidæ, contrasting with their moderate development in Canidæ, Viverridæ or Felidæ.

The teeth retain the molar formula of *Oligobunis*, *Amphictis*, etc., but $m\frac{2}{2}$ have become vestigial, and the form of the carnassials and of m^1 is partly modernized. P^4 comes nearest to *Mellivora* in form; m^1 is most like that of *Gulo*; the longitudinal shear of m_1 and absence of metaconid is seen in both genera and distinguishes *Megalictis* from *Oligobunis* in which the shear is more oblique and metaconid well developed.

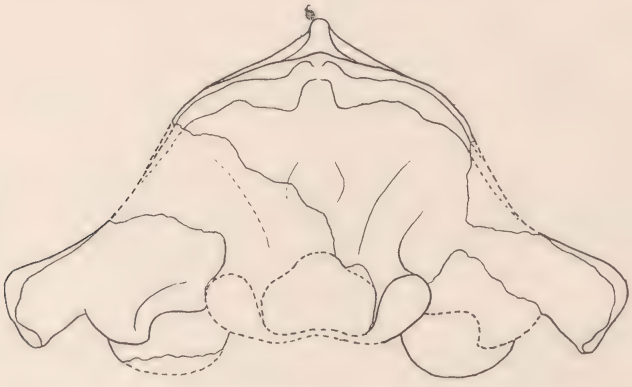


Fig. 13. *Megalictis ferox*, back view of skull, one half natural size. Type specimen.

With the fragmentary skull and jaws of the type specimen were found the greater part of the scapula, ulna, radius, and metacarpals I, II, and III complete but the characters of the skeleton are principally derived from the second specimen, No. 12881. This individual includes the humerus, tibia, and parts of other limb bones, all the metapodials except the pollex, a few carpals and phalanges, thirteen vertebræ, various ribs more or less complete, two sternal segments, and an os penis.

The humerus, radius and ulna are of about the same size as in *Amphicyon lemanense* but more robust; they are not so short as in *Mellivora*. The femur has a broad flat trochlea and the small patella is nearly as wide as it is long. The tibia and fibula are hardly more than half the size of those attributed to *A. lemanense* by Filhol, and are much like those of *Mellivora* but longer in proportion. The proportions of the metapodials are much

as in the ratel; they agree in size and robustness with *A. lemanense* as figured by Schlosser, but the hallux is much more reduced, and mt II of larger size, paired with mt V. The phalanges of the first row are more slender than in *A. lemanense* or in *Mellivora*. In *Gulo* the feet are much

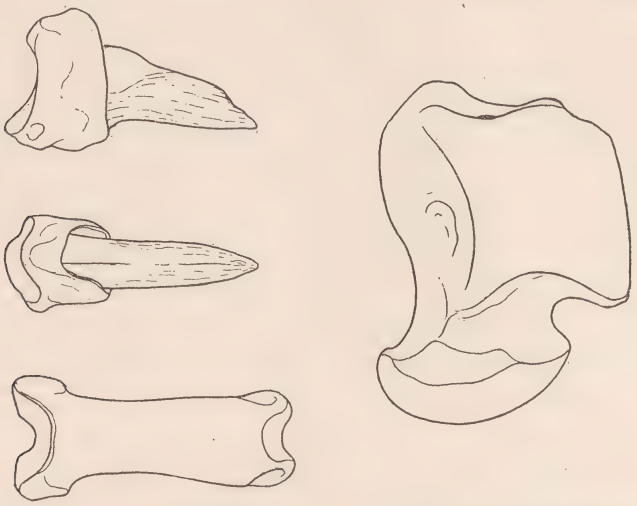


Fig. 14. *Megalictis ferox.* Astragalus, proximal and ungual phalanx, natural size. No. 12881.

more elongate, especially the phalanges, their proportions being much as in the smaller Mustelines. The single ungual phalanx preserved is quite unlike the compressed form seen in the bears, and intermediate in character between the unguals of the manus and of the pes in *Mellivora*. The astragalus is wider than in *Amphicyon*, the trochlea shallow, and limited in its backward extension, the astragalar foramen distinct, the neck of moderate length and the head somewhat flattened. It differs from *Daphœnus* in the more vertical position of the fibular facet, the trochlear crests parallel instead of divergent anteriorly, reduction of the posteroinferior process behind the trochlea, and other characters of modernization. The proportions and character of the metapodials are not unlike those of *Daphœnus* but also more modernized; the unguals differ widely and are not retractile.

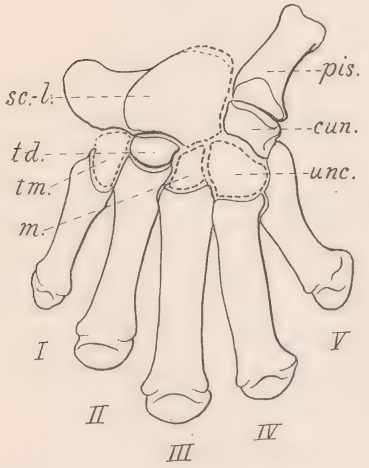


Fig. 15. *Megalictis ferox.* Left fore foot, one-half natural size. No. 12881. Metacarpals I and II from No. 12880.

The atlas vertebra, an anterior dorsal and parts of two others, two

posterior dorsals, four lumbars and three caudals are preserved in the second specimen, besides about a dozen ribs more or less complete. The relatively short, weak lumbars and long ribs indicate a short thick barrel as in *Mellivora*, instead of the long sinuous body of the weasels generally. *Gulo* is intermediate in this respect but more like the typical weasels. The anterior dorsal spines are rather short, expanded at the tip. The posterior dorsal and anterior lumbar zygapophyses are strongly convex and concave, but in the posterior lumbars they are flattened out assuming the form of cervical zygapophyses, and giving an unusual flexibility to the posterior lumbar region. The anterior caudal indicates a tail moderately large at the root, but the great length of the posterior caudals preserved shows that the distal portion was elongate and stout.

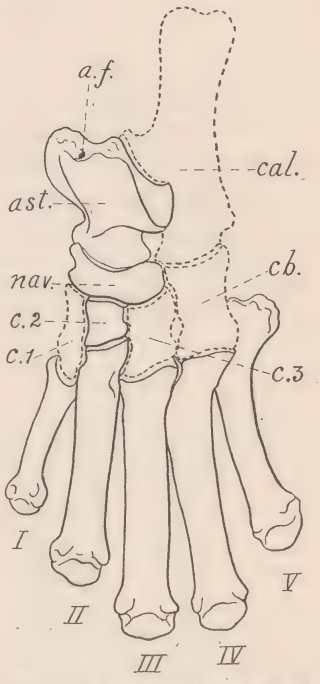


Fig. 16. *Megalictis ferox*. Left hind foot, one-half natural size. No. 12881.

The ribs are all of round-oval section in the shaft, with none of the flattening observed in modern Canidæ and many other carnivora. They are relatively long, and moderately stout. The segments of the sternum resemble those of *Mellivora* in form. The os penis is large, the shaft of subquadrate section enlarged at the butt, considerably curved upwards, reduced in diameter and channelled above toward the distal end. The tip is incomplete but apparently was recurved downward.

Measurements.

Type Specimen, No. 12880.	mm.
Length of skull, estimated	210.
Width at arches	164.
" " mastoid processes	140.
" across bullæ	83.
Distance from m^2 to glenoid fossa	56.
Transverse diameter of bulla inflated portion	20.
Diameters of p^4, anteroposterior 24.3; transverse	18.7
" " m^1 " 8.1; "	19.5
" " m^2 " 5.5; "	5.5
" " m_1 " 23; "	11.
" " m_2 " 7.3; "	6.2
Transverse length of condyle of lower jaw	49.
Width of coronoid process at base	42.

	mm.
Metacarpal I, length 36.7, diameter of shaft	6.5
" II " 51.8 " " "	9.1
" III " 57.6 " " "	9.2

Paratype, No. 12881.

Humerus, length 189; diameter of proximal end	53.
" diameter of distal end	59.5
Tibia, length, 172; diameter of proximal end	49.
" diameter of distal end	33.
Patella, length 28.5; breadth	24.1
Astragalus, length 36; width of trochlea	16.
Metacarpal III length 55.3; diameter of shaft	10.
" IV " 53.6 " " "	10.5
" V " 41.2 " " "	9.5
Length of a proximal phalanx 31.; diameter of shaft	8.5
Length of an ungual phalanx 28.; width of proximal end	10.5
Transverse diameter of distal end of radius	36.
Metatarsal I length 38.5; diameter of shaft	5.5
" II " 56; " " "	8.8
" III " 63; " " "	9.8
" IV " 64 (est.); " " "	9.7
" V " 55; " " "	9.
Atlas, length, 44.3; breadth	89.
Anterior dorsal, length of centrum 24; height to top of spine	75.
Posterior dorsal length of centrum 28; width of centrum	28.
Anterior lumbar " " " 28.5; " " "	30.
Posterior " " " " 35; " " "	30.
Anterior caudal " " " 20.5; " " "	18.5
Posterior caudal " " " 39; " " "	11.6
Posterior caudal " " " 39; " " "	11.6
Length of the longest rib preserved complete [1]	181.
Diameter of shaft of above rib	9.
Length of portion of os penis preserved	154.

Restoration of the skull.— The accompanying outline restorations of the skull (Figs. 10, 11, 13) of *Megalictis ferox* call for some explanation in regard to the restored parts. The extreme height of the forehead is not due to crushing nor to any error in restoration, the frontal bones and right maxilla being fairly complete and uncrushed. The maxilla is complete to the premaxillary suture as far down as the upper part of the canine alveolus, which appears on the inside of the bone. It is thus possible to determine the approximate position of the canine and the space behind it for the premolars without much margin of error. From the extremely short space between the roots of p^3 and the supposed position of the canine, it appeared

[1] Chord measurement.

probable that p^1 was absent and p^2 small and crowded. The size of the canine and incisors is conjectural, but the outlines of the front of the skull continued forward from the parts preserved, cannot be very far from correct, although the front teeth may have been more robust and more crowded than they are represented. The outlines of the anterior part of the lower jaw were drawn to correspond with the muzzle outlines, and the depth and robustness will be correspondingly greater if the front teeth are more robust. The back of the skull is sufficiently complete on one side or the other to render the outlines certain except in the parietal region. The basicranial region is not conjectural except a part of the border of the foramen magnum; elsewhere the base of the skull is perfectly preserved upon one side or the other as far forward as the carnassial. As the skull is completely uncrushed I do not think there is any possibility of considerable error except in the front teeth and the anterior part of the lower jaw.

Comparison with Ælurocyon Peterson.— After the description and figures of *Megalictis* were completed I was led to suspect that it might be identical with a large fossil musteline described by Mr. Peterson in a memoir of the Carnegie Museum now in press. Through the courtesy of Mr. Peterson I have been enabled to make comparison between the type of this genus and the type of *Megalictis*. The two are undoubtedly nearly allied, but there are several distinctions which I regard as of generic importance. The tubercular teeth are almost identical in the two; the upper carnassial in *Ælurocyon* is more elongate and has an antero-external basal cusp not present in *Megalictis*. The third upper premolar is evidently of quite different proportions so far as can be judged from the roots of that tooth preserved in *Megalictis*. The distance from the orbit to the premaxillary border is twice as great in *Ælurocyon*, allowing a much wider space for the premolars, which are three in number, while in *Megalictis* the space behind the canine (as judged from the course of the premaxillary border of the maxilla and from the part of the canine alveolus which is preserved) is so small that there can hardly have been more than two premolars between C^1 and p^4, and these smaller and more crowded than in *Ælurocyon*.

The outline of the skull is very different in the two genera. In *Ælurocyon* the muzzle is of moderate length and the frontals not nearly so high as in *Megalictis*, in which the muzzle is extremely short. The peculiar abrupt forehead of our genus is not due to crushing, and although the *Ælurocyon* skull is considerably crushed, it is quite clear that it lacked this peculiar feature and was much more elongate. The arch in *Megalictis* is much broader and heavier, the glenoid articulation and condyle nearly twice as wide. The length of the two skulls appears to have been about

the same. The basicranial region in *Ælurocyon* is not well enough preserved to make any exact comparison but does not appear to have been by any means so wide as in *Megalictis*.

I believe there can be no question of the generic distinctness of the two, nor that both belong to a group of Mustelines of which *Mellivora* and *Gulo* are the nearest living allies. *Mellivorodon* from the Siwalik beds also belongs to this group.

FELIDÆ.

Nimravus sectator sp. nov.

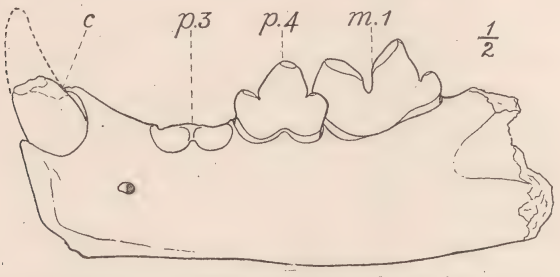


Fig. 17. *Nimravus sectator.* Outside view of type lower jaw, one half natural size.

The only felid specimen in the collection is a lower jaw clearly referable to the *Dinictis* group of sabre-tooth cats (*Dinictis, Nimravus, Ailurictis*) and provisionally referred to *Nimravus*. The species is larger and more robust than any of those from the John Day, and the flange of the jaw is reduced to a mere angulation, as in *Ailurictis*; there are two premolars of subequal size; the carnassial has the distinct heel and deep notch between paraconid and protoconid opening into a horizontal valley, and there is no trace left of the second molar. The post-canine diastema is unusually short.

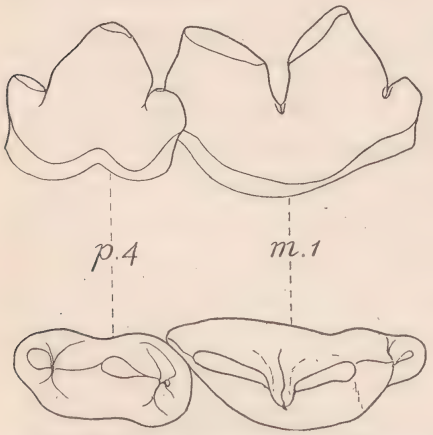


Fig. 18. *Nimravus sectator.* Outside and crown views of lower teeth, natural size. Type specimen.

This species may on better knowledge prove generically distinct from *Nimravus* and more or less directly ancestral to "*Machærodus*" *catocopis* of the Upper Miocene, which species I judge belongs to the *Dinictis* group and not to the true *Machærodi*.

Measurements of Type.[1] mm.

Length of dentition, canine to m^1	93.3
Length of post-canine diastema	16.
Diameters of alveolus of p^3 anteropost, 17; transv.	7.
Diameters of p^4, anteroposterior, 20.2; transverse	9.6
" " m^1 " 28.5; "	11.6
Depth of jaw in front of p^3	29.
" " " behind m^1	4.3

RODENTIA.

CASTORIDÆ.

Steneofiber *E. Geoffroy.*

This genus is abundant in the Lower Rosebud but has not been found in the upper beds. The species referred to it include a wide range of variation and should probably be divided into several distinct genera or subgenera. This, however, is best reserved until a larger series of skulls is accessible. The species from this formation, as well as those from the Harrison beds to the southwest, described by Peterson, appear to be more advanced and specialized than those of the John Day, which again show a distinct advance on the White River species. The Lower Miocene species are more numerous and include a wider range of divergence in size and proportions, and their teeth have longer crowns and in general a tendency to reduce the inflections to one principal external and one internal in the upper molars, one principal internal and one external in the lower; also to reduce the last molar. This appears to be an approximation to the *Dipoides* (*Eucastor*) pattern, in which the minor inflections have disappeared, the teeth are very hypsodont (?rootless) and the last molar reduced (said to be absent in *Sigmogomphius*). It is not unlikely that *Dipoides* (Upper Miocene) is descended from one of the Lower Miocene species of *Steneofiber*, among which *S. simplicidens* (infra) most nearly fulfills the required conditions. The skull of *Dipoides* has not yet been found unless *Sigmogomphius* Merriam be referable to this genus.

I have not been able to positively identify *S. barbouri* or *S. fossor* Peterson among our specimens, but some of the incomplete skulls and jaws may be referable to these species. The following appear to be clearly distinct:

Steneofiber simplicidens sp. nov.

Type, a skull, No. 12900, from the Lower Rosebud, found by W. D. Matthew.

Size intermediate between *S. barbouri* and *S. fossor.* Skull comparatively long and narrow, muzzle long and heavy. Sagittal crest moderate.

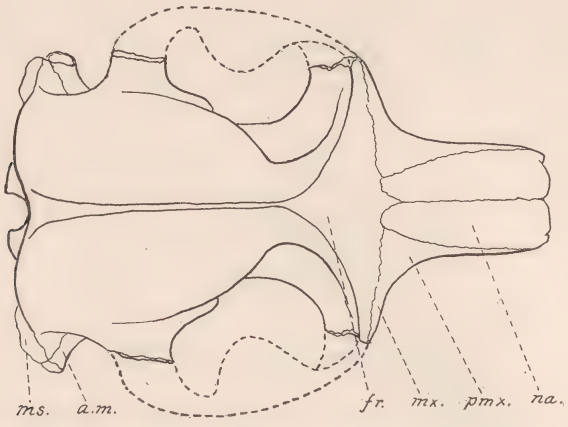


Fig. 19. *Steneofiber simplicidens.* Skull, top view, natural size. Type specimen. *A. m.*, auditory meatus; *fr.*, frontal bone; *ms.*, mastoid; *mx.*, *maxillary*; *an.*, nasal; *pmx.*, premaxillary bone.

Braincase and occiput not so wide as in the other species, except *S. nebrascensis*; bullæ rather small, intermediate between *nebrascensis* and the

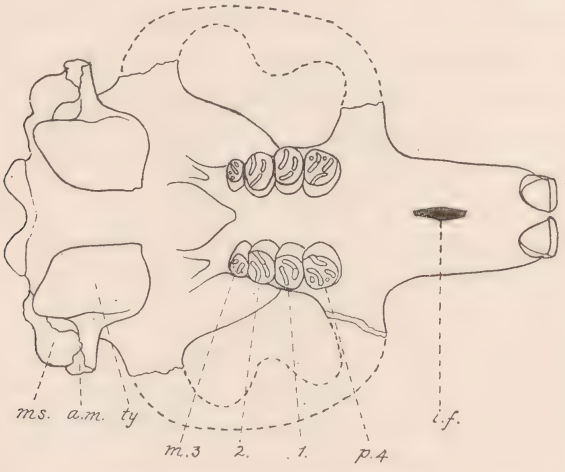


Fig. 20. *Steneofiber simplicidens.* Skull, base view, natural size. Type specimen. *A. m.*, auditory meatus; *i. f.*, incisive foramen; *ms.* mastoid exposure; *ty.*, tympanic bulla.

later forms. Incisors broad, diastema long, molars with long crowns, of rounded outline and simple pattern, the accessory external inflections having disappeared in the moderately worn tooth. Third molar much reduced.

Measurements.	mm.
Length of skull (incisors to condyles)	61.
Width of muzzle	13.
" " postorbital constriction	9.
" " occiput	34.5
Transverse diameter of bulla (excluding meatus)	7.
" " " incisor	4.
Length of diastema	20.5
Anteroposterior length of grinding teeth	12.5
Diameters of p^4, anteroposterior 3.7; transverse	4.1
" " m^1 " 3.4; "	4.2
" " m^2 " 3.2; "	4.1
" " m^3 " 2.3; "	2.8

Measurements taken at grinding surface.

Steneofiber sciuroides sp. nov.

Type, a skull, No. 12901, from the Lower Rosebud beds, found by W. D. Matthew. The species is about the size of *S. barbouri*, with shorter and wider skull, well rounded cranium without traces of postorbital or sagittal crests, and apparently a very low occipital crest. The nasals, occipital and basicranial bones are missing, so that complete comparisons cannot be made. The postorbital constriction is wider than in *S. barbouri*, the tooth rows less divergent posteriorly, the posterior nares open further forward, the jugal is deeper and the zygomatic process of the maxilla is nearly vertical, while in the other Steneofibers it slopes strongly forward superiorly. The full, capacious cranium, short, sharply defined muzzle, and very wide arches give this species a peculiar aspect. The teeth are much like those of *S. barbouri*.

Measurements.	mm.
Approximate length of skull, incisor to interparietal	51.
Width of skull across arches	46.
Width of muzzle	12.3
" " postorbital constriction	12.
Depth of zygoma	10.6
Width of palate at p^4	5.
m^3	5.9
Length of diastema	15.
Anteroposterior length of p^4–m^3	
Diameters of p^4, anteroposterior 3.6; transverse	3.3
" " m^1 " 2.9; "	3.4
" " m^2 " 2.9; "	3.4
" " m^3 " 2.8; "	3.

Diameters taken at grinding surface.

Steneofiber brachyceps sp. nov.

Type, a skull and jaws and fore limb bones, No. 12902, from the Lower Rosebud beds, found by Albert Thomson. The skull is as wide as that of *S. fossor*, but considerably shorter, with shorter muzzle, deeper jugal, well marked postorbital process on frontal as well as on jugal, shorter and deeper jaw, fore limb bones proportionately larger and more robust, The under side of the skull is not seen in its present state of preparation, nor the upper side of the jaws; the upper teeth appear to be unusually wide, but this may be due to wear.

Measurements.	mm.
Length of skull (approximate)	58.
Width at arches	49.
Width of muzzle	14.
" " postorbital constriction	9.6
" " occiput	43.
Depth of arch	16.
Length of lower jaw	46.
Depth beneath first molar	12.5
Extreme depth at coronoid process	33.4
Length of humerus	42
Transverse diameter at distal end	15.2
Anteroposterior diameter at head	8.7
Length of radius approximate	31.

Steneofiber ? pansus *Cope.*

Several skulls, parts of skulls, and lower jaws agree with the skull referred by Matthew and Gidley to this species. This skull, No. 10818, was found in a more easterly exposure of the Rosebud beds. The species appears to be common in the lower Rosebud. It is of the size of *S. barbouri* but is distinguished by its greater width, shorter muzzle and deeper zygomata. It was figured and described by Matthew and Gidley in Bull. Amer. Mus. Nat. Hist., 1904, pp. 257–260.

Euhapsis gaulodon sp. nov.

Type, a skull and lower jaws, No. 12897, from the Lower Rosebud beds, found by W. D. Matthew.

The species is distinguished from *E. platyceps* Peterson by its considerably greater length of skull. The arches are badly preserved, but do not appear to have been so wide or massive as in the type; the occiput has about the same width but considerably greater length, the muzzle is longer,

the sagittal crest widens a little in advance of the occiput into a broad raised area reaching forward to the postorbital constriction. The forward slope

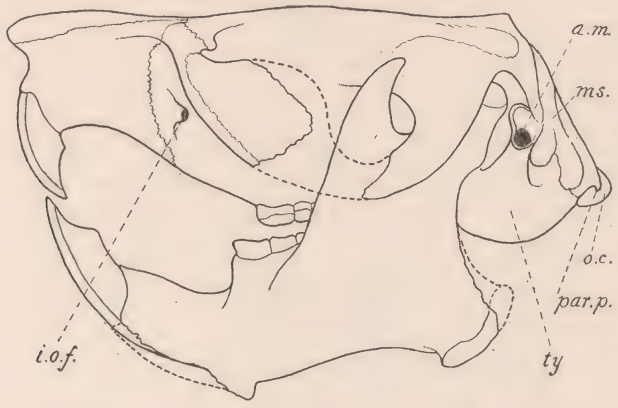


Fig. 21. *Euhapsis gaulodon.* Skull, side view, natural size. Type specimen. *A. m.*, auditory meatus; *i. o. f.*, infraorbital foramen; *ms.*, mastoid exposure; *o. c.*, occipital condyle; *par. p.*, paroccipital process; *ty.*, tympanic bulla.

of the occiput is conspicuous, as in the type. The teeth are all present and their general appearance confirms Peterson's suggestion of the Mylagaulid

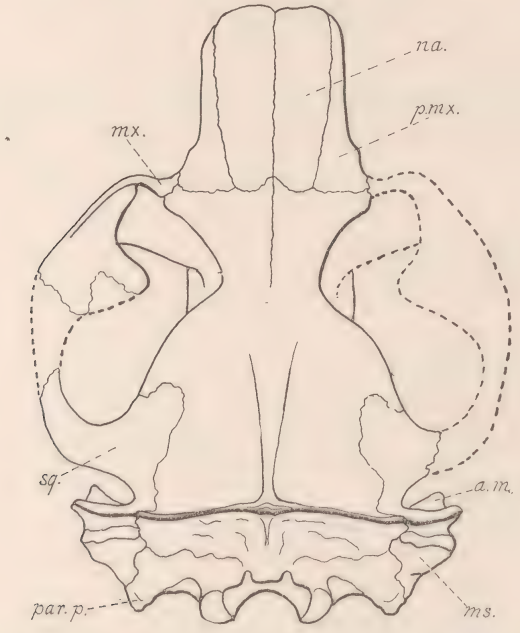


Fig. 22. *Euhapsis gaulodon.* Skull, top view, natural size. Type specimen. *A. m.*, auditory meatus; *ms.*, mastoid exposure; *mx.*, maxilla; *na.*, nasal; *par. p.*, paroccipital process; *pmx.*, premaxilla; *sq.*, squamosal bone.

affinities of this rodent. The relationship to *Steneofiber* is equally clear, the pattern being almost identical. It may be approximately although

not exactly ancestral to *Mylagaulus*, but a considerable change in the tooth proportions and pattern would be necessary to convert it into that genus.

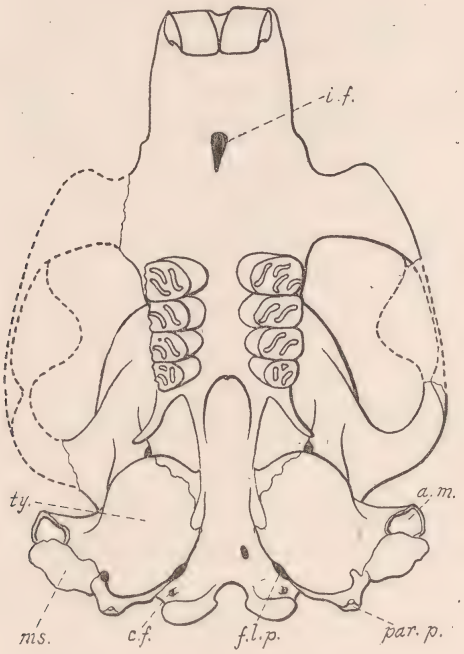


Fig. 23. *Euhapsis gaulodon.* Skull, base view, natural size. Type specimen. *A. m.* auditory meatus; *c. f.*, condylar foramen; *f. l. p.*, foramen lacerum poste rius; *i. f.*, incisive foramen; *ms.*, mastoid exposure; *par. p.*, paroccipital process; *ty.*, tympanic bulla.

Measurements.	mm.
Length of skull, incisors to condyles	68.
" " " nasals to occiput	56.5
Width of muzzle	13.7
" " postorbital constriction	11.
" " occiput including mastoids	40.
Slant height of occiput including condyles	25.3
Length of bulla (between stylomastoid and med. lac. foramina)	15.
Width " " (" postglenoid and carotid ")	12.
Length of upper dentition p^4–m^3	13.7
Diameters of p^4, anteroposterior 3.8; transverse	5.3
" " m^3 " 3; "	3.5
Width of incisor	4.1
Length of diastema between i and p^4	23.
Vertical height of occiput including tympanic bullæ	25.

GEOMYIDÆ.

Entoptychus *Cope.*

This genus has hitherto been known only from the John Day formation. It is rather common in the Rosebud beds, two well marked species being easily recognizable among our specimens. In both of these the skull is proportionately shorter than in any of the John Day species, with wider muzzle and greater development of the mastoid swelling. These, with various minor differences, while not of generic importance, are perhaps significant as indicating a trend of development somewhat in the direction of the modern *Heteromys*, although at the same time these species come nearer to *Thomomys* than do the types of the genus. The molars are rooted, and by definition these species should be referred to *Pleurolicus*, if the latter be regarded as a valid genus. But the distinction between the two genera is more nominal than real.

Entoptychus and *Pleurolicus* were referred by Prof. Cope to the Geomyidæ (Saccomyidæ), in which family the Heteromyidæ were then included. *Entoptychus* was described as with rootless teeth, *Pleurolicus* being distinguished by the rooted teeth. Cope called attention to their relationships to *Heteromys* on the one hand, to *Thomomys* and *Geomys* on the other. Scott, in describing the Uinta genus *Protoptychus* regarded it as ancestral to the Dipodidæ and *Entoptychus* and *Pleurolicus* as ancestral to the Geomyidæ. He emphasized the close relationship of Geomyidæ, Heteromyidæ and Dipodidæ, and concluded that the small development of the mastoid in some of the modern forms is due to degradation. Palmer in his Catalogue of the Genera of Rodents regards *Entoptychus* and *Pleurolicus* as Heteromyidæ, the former with doubt.

Entoptychus and *Pleurolicus* appear to be much nearer to the Geomyidæ, especially to *Thomomys*, than to any of the Heteromyidæ. The heavy, solid skull, with prolonged postorbital constriction, broad, long cylindrical muzzle, nasals not projecting beyond incisors, tubular meatus, moderately developed squamosal, wide incisors, long-crowned molars, and numerous minor features, ally them with the pocket gophers and separate them widely from the pocket-mice, even from *Heteromys*, which is the nearest of the modern Heteromyidæ. Unfortunately we know nothing of the skeleton of *Entoptychus*, and until the genus is proved to be fossorial or otherwise, we cannot be certain of its exact relationship to the modern genera of Geomyidæ. But on present evidence it should certainly be placed in this family. The ancestral types of the Heteromyidæ will perhaps be found in the imperfectly known Oligocene genera *Adjidaumo* (*Gymnopty-*

chus), and *Heliscomys*, and in still more fragmentary remains from the Miocene provisionally referred to *Heteromys*. The relationships of all these are conjectural until more complete specimens are found. It is probable that the common ancestry of Geomyidæ, Heteromyidæ, and Dipodidæ will be found in the group of Middle Eocene (Bridger) genera described from fragmentary material by Marsh and Leidy under the names of *Sciuravus*, *Mysops*, *Taxymys*, *Tillomys*, and *Colonomys*. The American Museum collections of 1903–1906 contain a fine series of specimens, including skulls and skeletons, of small rodents belonging to this group, and the preliminary studies now being made of them by Dr. F. B. Loomis will no doubt throw much light upon the origin of this group of the Rodentia.

Entoptychus formosus sp. nov.

Size equalling that of the smaller species of the John Day formation, but with broader muzzle, mastoid swelling larger, and numerous minor differences. Skull of moderate proportions, about as in *Thomomys*, but

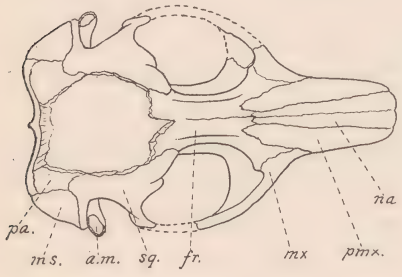


Fig. 24.

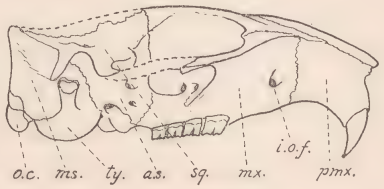


Fig. 25.

Fig. 24. *Entoptychus formosus.* Skull, top view, natural size. Type specimen. Lettering as in Figs. 19 and 22.

Fig. 25. *Entoptychus formosus.* Skull, side view, natural size. Type specimen. *As.*, alisphenoid bone; *i. o. f.*, infraorbital foramen; *ms.*, mastoid bone; *mx.*, maxilla; *o. c.*, occipital condyle; *pmx.*, premaxilla; *sq.*, squamosal bone; *ty.*, tympanic bulla.

with smaller brain-case, narrower and somewhat longer postorbital constriction, arches less expanded anteriorly, postorbital, sagittal and occipital crests better developed. Bullæ somewhat smaller than in *Thomomys*, more like those of *Heteromys*. Mastoid swelling more than in *Thomomys*, less than in *Heteromys*. Nasals not prolonged forward as in Heteromyidæ, like those of Geomyidæ but reaching further backward. Postorbital constriction long and narrow, postorbital ridges prominent, uniting at a short distance behind the constriction into a low sagittal crest and separating again before reaching the occiput so as to enclose with the occipital crest a triangular raised area as wide as the interorbital space. The attachment of the masseter muscle is defined above by a sharp crest on the upper edge

of the arch, which is carried forward as a prominent ridge to and beyond the anterior border of the maxilla at the junction of the lateral and superior surfaces of the muzzle. This crest is more prominent than in the John Day *Entoptychi* or in *Thomomys*, more as in *Heteromys*.

Incisors of moderate width and slightly convex on the outer surface. Molars and premolars like those of the John Day *Entoptychi*, the crowns very long, but with closed roots in old age.

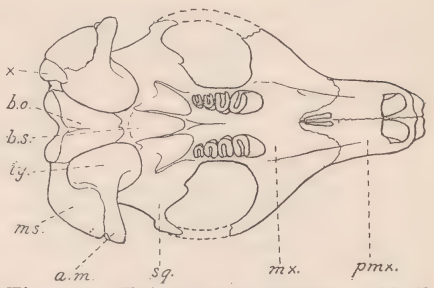


Fig. 26. *Entoptychus formosus.* Skull, base view, natural size. Type specimen. *a. m.*, auditory meatus; *b. o.*, basi-occipital; *b. s.*, basisphenoid; *ms.*, mastoid; *mx.*, maxillary; *pmx.*, premaxillary; *sq.*, squamosal bone; *ty.*, tympanic bulla; *x*, a small accessory bone overlapping the mastoid and occipital at their junction with the tympanic.

The type is a nearly perfect skull, No. 12887, found by Mr. Thomson in the Upper Rosebud beds. Other skulls and lower jaws are referred to this species.

Measurements.	mm.
Length of skull (incisors to condyles)	40.1
Width across arches (estimated)	24.
" " mastoids, behind auditory meatus	22.1
Height of occiput	11.3
Width of postorbital constriction	5.6
Height at " " (including molars)	15.3
Width of muzzle at middle of nasals	9.
Width of incisor	2 1
Length of diastema	12.8
Length of grinding teeth p^4–m^3 at alveolar border	8.3
Width of palate at p^4 (exclusive of teeth)	2.2
" " " " m^3 (" " " ")	3.8
Length of auditory meatus	4.5
Transverse diameter of bulla	5.
Diameter of p^4, anteroposterior 2. ; transverse	2.5
" " m^1 " 1.5; "	2.3
" " m^2 " 1.3; "	2.
" " m^3 " 1.5; "	1.6

Entoptychus curtus sp. nov.

Size a little less than *E. formosus*, muzzle somewhat shorter, postorbital constriction much shorter and somewhat wider, without postorbital crests; sagittal crest low and narrow, extending forward to the posterior part of the postorbital constriction, triangular area at junction of sagittal and postorbital crests minute. Teeth as in the preceding species but p^4 slightly larger.

Type, No. 12890, a skull from the Upper Rosebud beds, found by Mr. Gregory. Other specimens from the Upper and Lower beds are referred to this species.

Measurements.	mm.
Length of skull, incisor to condyle	39.
Width behind auditory meatus	22.8
Height of occiput	11.
" at postorbital constriction (including molars)	13.4
Width of muzzle at middle of nasals	8.4
" " postorbital constriction	6.5
Length of diastema	13.1
Length of p^4–m^3 at alveolar border	8.
Diameter of p^4 (No. 128.91), longitudinal 2.3; transverse	2.6
" " m^1 " 1.8; "	2.3
" " m^2 " 1.4; "	2.
" " m^3 " 1.5; "	1.7

The measurements are from the type except as noted.

HETEROMYIDÆ.

A lower jaw from the Upper Rosebud beds indicate what is probably an undescribed genus of this family. The teeth are very like those of *Heteromys*, but the posterior lobe of m_3 is larger and the anterior lobe of p_4 smaller in proportion. The size is considerably larger than any of the modern species of this genus, the diastema longer, and the incisor directed more forward. The coronoid process is less reduced, and the prominence at its base on the external side of the jaw is much more pronounced. In this and several other respects the conformation of the jaw approaches that of *Pleurolicus*, but the incisors have the narrow rounded form of the Heteromyidæ. It probably indicates an intermediate genus which cannot at present be adequately defined.

A second much smaller Heteromyid is indicated by a part of the lower jaw with p_4–m_1 preserved. The premolar is proportionately small, as in the larger species.

LEPORIDÆ.

Lepus macrocephalus sp. nov.

This species belongs to the primitive group represented by *L. ennisianus* of the John Day, intermediate between *Palæolagus* and the typical modern hares. The type specimen, No. 12910, consists of a lower jaw with fore and hind feet of both sides and parts of the limbs, etc. It is a more robust and considerably larger species than *L. ennisianus*, and like it has three

columns on the outer side of p_2, but the furrow between the two anterior columns shallow as compared with modern *Lepus*. The last molar is much reduced, as in *Palæolagus*. The jaw is short, deep, and heavy, equalling *L. campestris* in size but with shorter diastema.

The limb bones and feet are much smaller than in *L. campestris*, nearer to *L. virginianus* in size and proportions. It is of interest to observe that in the elongation and specialization of the limbs and feet the Lower Miocene Leporidæ, in this species at least, were practically as far advanced as any of their modern descendants. Vestiges of the former primitive five-toed short-footed conditions appear more clearly than in the modern hares, and there are also accessory ossicles on the *dorsal* surface of the proximal ends of mc. II and III and of mt. II, presumably associated with peculiar conditions of the carpal and tarsal extensor tendons, which require further study for their explanation. But in proportions and in character of the articulations the podials, metapodials, and phalanges, and what can be seen of the limb bones, compare nearly with the typical *Lepus*, and would place the species in this genus rather than in the short-limbed group of modern Leporidæ (*Sylvilagus, Caprolagus*, etc.).

It is remarkable that palæontology has thrown so little light upon the relations of the Lagomorpha to the remaining Rodentia. No Eocene Rodents show any approximation to this group; they appear suddenly in the Oligocene, already abundant and highly specialized, the Leporidæ in North America, the Ochotonidæ Lagomyidæ in Europe, and have changed comparatively little from that epoch to modern times. Judging from their rate of evolution these two closely related families must have diverged during the Eocene, and the splitting off of the Lagomorpha from the main rodent stock must date well back in the Cretaceous. From the entire absence of related forms in the Eocene of Europe, the two Americas and Africa, it is fair to assume that they did not develop upon any of these continents; they are undoubtedly a northern type, and Asia appears the most probable place of origin.

Measurements. (Type of *L. macrocephalus*.) mm.

Length of lower dentition p_2–m_3	15.7
" " diastema of lower jaw	15.
Depth of jaw beneath p_4	13.
Length of mc I 5.5; diam. distal end	2.5
" " " II 20.1; " " "	3.7
" " " III 22.9; " " "	3.6
" " " V 12.5; " " "	3.8
Length of proximal phalanx, digit II	10.5
" " " " " III	11.3
" " " " " V	10.5

	mm.
Length of middle phalanx, digit V	6.2
" " ungual " forefoot	9.
Length of calcaneum	24.9
Length of mt. II 42.3; diam. distal end	4.5
" " " III 43.; " " "	4.5
" " " IV 41.6; " " "	4.7
" " " V 37.; " " "	4.7
Length of a proximal phalanx (III or IV)	18.6
" " median " "	8.8
" " ungual " "	10.
Total length of manus	52.2
" " pes	109.

Lepus primigenius sp. nov.

A second smaller species of similar type to *L. macrocephalus* is indicated by a single lower jaw, No. 12911. The teeth are like those of the larger species except in size, the jaw is not so deep and the diastema proportionately longer, although short in comparison with most of the modern Lepores.

DICOTYLIDÆ (TAGASSUIDÆ).

The Suidæ, Elotheriidæ and Dicotylidæ are apparently derived from a common Eocene ancestry and the Dicotyline group is first clearly distinguishable from the others in the Oligocene *Perchœrus*. The skeleton of this genus is unknown; the skull differs from modern peccaries chiefly in the small braincase, simple premolars, full Eutherian dentition and simple round bulla without cancellous tissue. In all upper Miocene, Pliocene, Pleistocene, and recent species the upper incisors are reduced to two, the premolars are more or less completely molariform, p_1 is absent, the bullæ are filled with cancellous tissue, and the brain is of much larger size. These characters are common to *Dicotyles, Platygonus, Mylohyus,* and *Prosthennops,* and each of these genera shows various divergent specializations in addition to the common progressive characters.[1]

The Lower Miocene peccaries are intermediate in the progressive characters common to all the genera, and might be ancestral to any or all of them. Peterson has described and figured a species from the Harrison beds of Nebraska under the name of *Thinohyus siouxensis*. The typical *Thinohyus* is from the Oligocene (John Day) and neither Peterson nor Sinclair make any attempt to distinguish it from the previously described *Perchœrus* of the White River. Skulls of *Perchœrus* in the American Mu-

[1] See Matthew and Gidley, Bull. A. M. N. H., 1904, p. 265.

seum show the two to be very closely related, and I do not know of any valid generic distinctions. "*Thinohyus*" *siouxensis* is, however, distinguished from *Perchœrus* and the typical *Thinohyus* by the following characters: (1) Lateral incisors reduced, median incisors enlarged. (2) P_1 absent. (3) Bullæ filled with cancellous tissue.

A nearly related species from the Rosebud shows in addition to these characters some degree of premolar complication. It appears therefore, as Mr. Peterson has already suggested, that *T. siouxensis* should be separated from the Oligocene species, as a distinct subgenus at least, and this is more clearly evident in the Rosebud species, which may be regarded as generically distinct.

Desmathyus gen. nov.

This genus is designed to include peccaries with three upper incisors but the lateral incisor reduced or vestigial and the median enlarged, the first lower premolar absent, premolars beginning to be molariform, bullæ filled with cancellous tissue. Proportions of skull much as in *Perchœrus* (*Thinohyus*) and *Dicotyles*, but braincase much smaller than in the modern genus. In *Perchœrus* the incisors are of equal size and the dentition complete, the premolars simple and the bulla not cancellous. In all the later genera there are but two incisors; in *Dicotyles* the median one is enlarged, in *Prosthennops* and *Mylohyus* both are vestigial, and the muzzle elongate. In *Platygonus* the crowns of the teeth are higher and crested transversely. In *Prosthennops*, *Mylohyus*, and *Dicotyles* the premolars are more completely molariform.

As type of the genus I take the species described below, and refer to it "*T.*" *siouxensis* as a primitive marginal form transitional from *Perchœrus*.

Desmathyus pinensis sp. nov.

Type, a skull and part of lower jaw from the upper Rosebud, No. 12936, found by W. D. Matthew. Two other skulls, one with lower jaws complete, the other with lower teeth only, and a lower jaw with fragments of the skull are referred to the species. All are from the same horizon and locality.

The species is distinguished from *D. siouxensis* by greater reduction of i^3 and enlargement of i^1; p^1 two-rooted, close to p^2 and separated from c^1 by a diastema; premolars broader and p^3 with well developed deuterocone and posterior heel; skull larger and proportionately broader, especially in the muzzle. The lower jaw is deeper and less angulate beneath the

symphysis; the fourth premolar in the type has a crest representing the entoconid, but in all the referred specimens the entoconid is a distinct cusp. In *D. siouxensis* it is not present.

Measurements. (Type specimen, No. 12936.) mm.

Skull, length from incisors to occiput	310.
" " " " " condyles	270.
" width at zygomata	141.
Muzzle, width at canines	70.6
" " across postorbital processes	107.
Occiput height	108.7
Upper dentition, length	166.6
Palate, width across m^2	71.2
Diameters of i^1, anteroposterior 12; transverse	15.
" " i^2 " 9.; "	8.2
" " i^3 " 5.2; "	4.8
" " c^1 " 17.; "	11.
" " p^{1-4}, length	48.4
" " m^{1-3}, "	60.3
Length from canine to m_2, lower jaw	106.7
" of three lower premolars	38.
Lower jaw depth beneath m_1	41.5
Skull No. 12938.	
Length from incisors to occiput	337.

HYPERTRAGULIDÆ.

Hypertragulus ordinatus sp. nov.

Larger than the type of the genus (*H. calcaratus*), about equal in size to *H. hesperius* Hay from the John Day. Distinguished from either species by the closing of the diastema between p_2 and p_3 and great reduction of the diastema between c_1 and p_1, in the lower jaw. The length of the diastema between (the caniniform) p_1 and p_2 is increased, so that the general proportions of the jaw are about the same. Molar crowns more hypsodont than in *H. hesperius*, about as in *H. calcaratus*. P_1 and p_2 are shorter and proportionately higher than in the John Day species, but less reduced than in the White River species.

Two or more undescribed species of *Hypertragulus* are indicated by fragmentary material in our collections from the White River, and at least one from the John Day. In one of the White River species the anterior diastema is closed, a fact that Prof. Cope had evidently observed, as he had given the fragments an appropriate manuscript name. But the diastema between p_2 and p_3 is found in every Oligocene specimen that I have seen; its disappearance may therefore be a mark of progress of the genus.

The type, No. 13011, is a complete lower jaw from the Lower Rosebud beds of Porcupine Creek. The genus is represented by various fragmentary specimens, probably of this species, all from the lower beds. In the Upper Rosebud it is replaced by *Blastomeryx*. The specific name refers to the compact ranking of the teeth resulting from closure of the lesser diastemata.

ANTILOCAPRIDÆ.

Merycodontinae.

Blastomeryx *Cope.*

True ruminants (Pecora) are common in the Middle and Upper Miocene of this country, but are not found in the Oligocene. We have found no trace of them in the Lower Rosebud fauna but in the Upper Rosebud are two species referable to *Blastomeryx* Cope, a Middle and Upper Miocene genus nearly related to *Merycodus* Leidy but with more brachydont teeth.

This genus is evidently an immigrant type, and the only member of the fauna not derivable from the White River and John Day faunæ. The manus and pes are typically pecoran and in no respect transitional from any of the Hypertragulidæ of the Oligocene.

Blastomeryx advena sp. nov.

The type is a lower jaw, No. 13014, which agrees quite nearly with *B. gemmifer* of the Pawnee Creek beds but is considerably smaller. A second lower jaw, No. 13016, with a few skeleton bones, indicates a larger variety or distinct species. A third specimen No. 13015, with a considerable part of the skeleton but no skull parts, probably belongs to this genus. It shows the structure of manus and pes almost identical with that of *B. gemmifer*.

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Article X.— ON A COLLECTION OF AUSTRALIAN AND ASIATIC BEES.

By T. D. A. Cockerell.

The bees which form the subject of this paper belonged to the collection of the well-known entomologist Henry Edwards, and are the property of the American Museum of Natural History. Mr. Beutenmüller informs me that the Australian specimens were collected by W. Macleay, but the collectors of the others are unfortunately unknown. Of peculiar interest is the little series from Amboina. So far as I can ascertain, ten species of bees have been recorded from that island; eleven are now added, making a total of 21. The first records were three by Fabricius in 1804, based on specimens obtained from Billardièr. These Fabrician species were very briefly described; one of them, a *Crocisa*, was supposed to be well-known, but a topotypical specimen now before me shows that the species has been misunderstood; the second, a *Megachile*, is not known to modern writers, unless it is identical with one later described by Smith — as is indeed probable; the third, supposed to be an *Anthophora*, is unknown to-day, but the abdomen has a single conspicuous fulvous band, which should make the insect easily recognizable. There are some things in the brief description of the last which are rather suggestive of *Megachile*.

The next record was that of an *Apis* by LeGuillou in 1841. This also has not been recently recognized; the two species of *Apis* in the present collection from Amboina are common and widespread forms. Dalla Torre, in his Catalogue, erroneously gives the locality of *Apis gronovii* as Timor.

Smith in 1860 described three species, one of *Xylocopa* and two of *Megachile*, collected in Amboina by Wallace. Radoszkowski in 1894 added a *Crocisa* discovered by Doleschall. Pérez in 1901 recorded a *Xylocopa*, and Friese in 1905 a third *Crocisa*.

The complete list is as follows; the species marked with an asterisk are added in the present paper:—

Apis gronovii LeGuillou.
" *dorsata* Fabricius.*
" *indica* Fabricius.*
Xylocopa unicolor Smith.
" *confusa* Pérez.
" *mohnikei* Ckll.*
Anthophora vigilans Smith.*
" *elegans* Smith.*
" *wallacei* Ckll.*
" (?) *fulvata* (Fabricius).
Megachile frontalis (Fabricius).
" *lachesis* Smith.
" *ventralis* Smith.
" *doleschalli* Ckll.*
" *dampieri* Ckll.*
" *funnelli* Ckll.*
Crocisa novæhollandiæ Lepeletier.*
" *amboinensis* Radoszkowski.
" *nitidula* (Fabricius).
" *nigrescens* Friese.
Nomia amboinensis Ckll.*

The neighboring islands Ceram and Bouru have the following records:—

Nomia concinna Smith.— Ceram.
" *simillima* Smith.— Ceram.
Xylocopa unicolor Smith.—Ceram, Bouru.
Nomada insularis Smith.— Ceram.
Megachile funeraria Smith.— Bouru.
" *punctilollis* Friese.— Bouru.

Melipona atrata (Fabricius), cited by Dalla Torre as from Amboina, is American.

Megachile macleayi sp. nov.

♀. Length just over 17 mm.; abdomen of the parallel-sided type; wings dark fuliginous, shining purple, the apical margins broadly paler; black, seen from above the only conspicuous pubescence is snow-white, covering the scutellums and metathorax, and a bright orange-red patch covering the fifth and sixth, and a large part of the fourth, abdominal segments. Head massive and subglobose, face very broad, the eyes slightly converging above; face at sides and about antennæ, and cheeks below, with thin grayish-white hair; clypeus with rather pale fuscous hair, not conspicuous, a fringe of orange hair beneath its lower margin; antennæ entirely black; vertex with dense large punctures, and minute ones interspersed; a shining ridge descending from each lateral ocellus, the two forming a sort of large U, with the lower part wanting; clypeus transverse, very broad, its anterior margin simple, its surface very densely punctured; mandibles with three large teeth; tegulæ black; mesothorax densely and coarsely rugoso-punctate; tubercles with a dense fringe of white hair; legs black, with inconspicuous dull hair, that on inner side of basal joint of hind tarsi reddish fuscous, contrasting with a tuft of pure white at apex of tibiæ; hind spurs piceous; first abdominal segment with white hair; second and third segments bare and shining, with large punctures; sides of fourth segment bare except apically; ventral scopa creamy white, fuscous on the last two segments.

Hab.— New South Wales (Am. Mus. Nat. Hist., 299).

A very remarkable and beautiful species, somewhat recalling *M. albobasalis* Sm., from Murray Island, Torres Strait, but very distinct from that and all others. There is probably some affinity with the Tasmanian *M. leucopyga* Sm.

Megachile beutenmulleri sp. nov.

♂. Length 10½ mm.; black, abdomen parallel-sided, with a large patch of bright orange-red tomentum occupying the fifth segment except at sides, and the adjacent apical margin of the fourth; head large, face densely covered with pale yellow hair; vertex with a mixture of short dark fuscous and long pale hair; cheeks beneath with a beard of pure white hair; vertex densely punctured; antennæ entirely black; clypeus normal; thorax with long white hair; black interspersed on mesothorax, and a little on scutellum; viewed from the side, the front of the mesothorax appears white-haired, and the region immediately behind this black-haired; mesothorax shining, densely punctured; legs black, with white hair; anterior coxæ densely covered with white hair in front, and unarmed; anterior tarsi slender

and simple; tegulæ black; wings hyaline, upper half of marginal cell dusky; first abdominal segment with white hair, and a white patch on each side of second posteriorly; third and fourth segments with short black hair; sixth broadly emarginate, the sides of the emargination very obtuse; seventh not spined; under side of abdomen with white hair.

Hab.— Victoria (Am. Mus. Nat. Hist. 302).

Somewhat related to *M. erythropyga* Sm. and *M. canifrons* Sm.

Megachile henrici sp. nov.

♀. Length about 14 mm.; black, the face covered with bright orange-ferruginous hair, and the apical dorsal segment of the abdomen nearly covered by tomentum of the same color. Head large, facial quadrangle about square, eyes slightly converging above; vertex with short dark fuscous hair, occiput with long pale hair; antennæ entirely black; clypeus transverse, its edge somewhat crenulate, but otherwise simple; mandibles stout, with two large teeth, and a subapical band of fulvous hair; cheeks broad, white-haired; thorax with much white hair, a little black intermixed on mesothorax; mesothorax shining, rather shallowly rugoso punctate; wings dusky, not very dark, upper half of marginal cell fuscous; legs black, with white hair; hind spurs black; hair on inner side of basal joint of hind tarsi dark fuscous; claws with a conspicuous diverging basal tooth; first abdominal segment with white hair, lateral hind margins of second with conspicuous white hair patches; remaining segments, except the red apical patch, with short black hair; ventral scopa silvery white, black at sides of last three segments.

Hab.— New South Wales (Am. Mus. Nat. Hist., 301).

In my table in Ann. Mag. N. H., June 1906, this runs to 5, and runs out because the wings are not very dark and the abdomen is not banded. It is quite distinct from all the described species.

Megachile maculariformis sp. nov.

♀. Length a little over 12 mm.; black, the hair of the face light bright orange-fulvous, and the tomentum covering the apical abdominal segment of the same color; abdomen broad, shovel-shaped, the segments transversely grooved, and their hind-margins having narrow entire pure white hair bands, except the penultimate one, which has the band colored like the apical patch; the hair before all these bands is coarse and black, except that the greater part of the first segment is covered with long white hair; ventral scopa pure white, black at extreme sides except on first segment, entirely black on apical segment, and largely black on apical half of penultimate one. Head large, antennæ entirely black; hair of vertex fuscous; clypeus normal; mandibles with three teeth, not counting inner corner; cheeks with white hair; pleura and metathorax with much white hair; hair of thorax above mostly black; spots of dense pure white hair on tubercles, just above tegulæ, and a pair of transverse ones in scutello-mesothoracic suture; mesothorax and scutellum very densely punctured; tegulæ rufo-piceous; wings dusky, but not fuliginous; legs black, with white hair, the femora and anterior tibiæ dark reddish with white

hair; hair on inner side of hind tarsi dark fuscous; basal joint of hind tarsi broadened; claws with a basal tooth.

Hab.— New South Wales (Amer. Mus. Nat. Hist. 303).

Allied to *M. macularis* D. T., but differing in color of antennæ, of abdominal bands, etc.

Megachile modesta *Smith.* New South Wales. Clypeus emarginate, the sides of the emargination shining; apical segment of abdomen black, but with orange pile. This must be the true *modesta*, and the species reported as *modesta* in Ann. Mag. Nat. Hist., June, 1906, p. 531, should apparently be known as *M. apicata* Smith.

Megachile devadatta sp. nov.

♂. Length 11½ mm.; expanse over 19; length of abdomen about 5. Black with red legs, and dullish fulvous hair, passing into white below; the abdomen short and truncate. Face densely covered with pale yellowish hair, except the upper part of clypeus, where the densely punctured but shining surface is bare; under side of head with long white hair; flagellum obscure reddish beneath, last joint not in the least broadened; mesothorax and scutellum as densely punctured as is possible, but the narrow dividing lines between the punctures shining; hair of thorax above fox-red, not hiding the surface; tegulæ pale ferruginous; anterior coxæ black, with stout but only moderately long spines; anterior femora, tibiæ and tarsi entirely bright ferruginous, the tarsi somewhat broadened and flattened, but without any very peculiar features; middle femora red above and apically, otherwise blackish, their tibiæ red, but their tarsi long and black with much long yellowish-white hair; hind legs colored much like the middle ones, but their tibiæ much blackened apically, and decidedly curved; hind tarsi with the basal joint broad but not long, the apical joint very long and slender; claws with the basal half pale fulvous, the apical black, strongly bifid but with no basal tooth; spurs pale fulvous, hind spur minutely ciliate; wings subhyaline, strongly reddish; second s. m. below a trifle longer than first; abdomen black, with a deeply excavated basin at base, its edge sharp; first segment with much fox-red hair; second and third with rather narrow, uniform, pale fox-red hair-bands; beyond this the light bands are dull whitish, and the dark surface shows many black bristles; apical segment vertical, its margin broadly subtruncate, obscurely crenulate of tuberculate, with a feeble median emargination; no subapical ventral spines; ventral segments fringed with white hair.

Hab.— Northern India,— no other particulars known (Am. Mus. Nat. Hist).

Allied to *M. buddhæ* D. T., but that has the margins of the abdominal segments and the apex of the mandibles ferruginous.

Megachile doleschalli sp. nov.

♀. Length about 13 mm.; expanse 21; black, with fox-red hair, especially on abdomen, which is elongate shovel-shaped. Hair of front and sides of face pale ferruginous, but of clypeus (except the extreme sides) coarse and black; antennæ

black; clypeus very densely and coarsely punctured, except upper margin, and a less decided median line, which form a sort of smooth shining T; anterior edge normal; mandibles black; with a dull red spot at base of second tooth, 4-dentate, the two apical teeth long and narrow, the third in the form of a very broad triangle, the fourth a little tubercle; no subapical band of hair; hair of vertex and thorax above fox-red, sparse in middle of thorax; mesothorax and scutellum shining, with strong punctures, dense laterally, but on disc separated by spaces fully equal to their diameter; at sides of metathorax and below wings the hair is copious and fox-red, on lower part of pleura it is scanty and pallid; tegulæ light rufo-fulvous; wings dusky, strongly reddish, nervures and stigma ferruginous; legs black, a reddish spot at apex of tibiæ; tarsi with fulvous hair; hind basitarsus (basal joint of hind tarsus) broad and flat, at least as long as the other joints together; spurs ferruginous; claws simple apically, but with a basal tooth; abdomen black with fine punctures, covered above with fine fox-red hair, which is dense and bright on the hind margins of the segments, forming bands against a duskier (but still red-haired) ground; scopa bright ferruginous, a few black hairs on the apex of the last segment.

Hab.— Amboina (Am. Mus. Nat. Hist.).

Named after Dr. Doleschall (*cf.* Wallace, Malay Archipelago, p. 224). This looks just like a small edition of the African *M. fulva* Smith, except that that has a dull mesothorax.

Megachile dampieri sp. nov.

♂. Length about 11 mm.; expanse 20; length of abdomen (which is of the parallel-sided truncate type) about 5. Black, with fulvous hair, that on head yellowish-white or very pale yellow. Face densely covered with yellowish silky hair; ocelli ferruginous; vertex dull, cribrately punctured, with rather thin long erect yellowish hair, and a little fuscous at the sides; antennæ long and slender, black; mandibles shining black, strongly elbowed; hair of thorax long and not very bright, not hiding surface; some black hair on scutellum, and even a little on hind part of mesothorax; mesothorax and scutellum with large shallow punctures separated only by their raised edges, giving the whole a fine reticulation, with something the appearance of the surface of the moon; pleura also contiguously punctured; tegulæ dark reddish; wings dusky, strongly reddish, nervures and stigma rather dark ferruginous, stigma rather smaller than in *M. doleschalli*; middle and hind legs black, their tarsi reddened, with very long fulvous hair; anterior femora and tibiæ red, black on the outside; their tarsi cream-color, the joints flattened but only moderately broadened, the first joint with a fringe of white hair on its lower margin; anterior coxæ with black spines; middle tarsi short and flattened, the hind margin with exceedingly long hair; hind tarsi elongated, longer than the tibiæ; spurs ferruginous; claws bifid; abdomen with fox-red hair, quite bright, dense on the hind margins of the segments, forming rather obscure bands; apical segment vertical, with some erect dark hairs, its margin strongly emarginate; very small lateral subapical ventral spines.

Hab.— Amboina (Am. Mus. Nat. Hist.).

Looks at first sight like the male of *M. doleschalli*, but the sculpture of the thorax is entirely different.

Megachile funnelli sp. nov.

♀. Length about 8⅓ mm.; black, the middle and hind femora bright ferruginous except at extreme apex; ventral scopa white, very short and somewhat fuscous on last segment. Head large, oval, with a broad vertex, *Heriades*-like; hair of head and thorax very scanty, dull white; antennæ wholly dark; clypeus with very large contiguous punctures, the anterior edge straight; supraclypeal area with the punctures even a little larger, but not so dense; front and vertex cribrately punctured. the punctures of the vertex enormous; mandibles broad, with two strong apical teeth, the other two teeth represented merely by an undulating margin; mesothorax and scutellum nude, with very dense small punctures, hardly half the size of those on vertex; punctures of pleura a little larger than those of mesothorax; tegulæ dark, with a reddish tint; wings dusky, but not very dark; stigma and nervures dark ferruginous; b. n. falling only a little short of t. m.; stigma quite large; legs black except the red middle and hind femora; hind basitarsus broad and flattened, with orange-fulvous hair on its inner side; spurs ferruginous; no pulvillus; claws simple, no basal tooth; abdomen densely punctured, with very narrow white hair-bands on the margins of the segments; punctures on raised part of third and fourth segments relatively large.

Hab.— Amboina (Am. Mus. Nat. Hist.).

Named after William Funnell (*cf.* Wallace, Malay Archipelago, p. 224), who visited Amboina in 1705. This species strongly recalls some of the little Heriadiform Australian forms.

The following table separates the known Amboinese species of *Megachile*:—

	Very large with entirely black pubescence; wings fuliginous .	*lachesis* Smith
	Smaller, hair not all black	1.
1.	Abdomen with fulvous or red hair above; scopa of known females red .	2.
	Abdomen not fulvous-haired above	3.
2.	Middle of mesothorax shining, with well-separated punctures	*doleschalli* Ckll.
	Middle of mesothorax dull, with a minute raised reticulation	*dampieri* Ckll.
3.	Size small; abdomen with narrow white hair-bands; scopa white	*funnelli* Ckll.
	Larger, over 10 mm. at least; abdomen without light hair-bands . .	4.
4.	Front and clypeus with white hair	*frontalis* (Fabr.).
	Face with yellowish white hair in male; front of head and sides of thorax with black hair in female; scopa bright ferruginous . . .	*ventralis* Smith.

It is quite possible that *ventralis* is the same as *frontalis*; the short Fabrician description appears to agree with the male of *ventralis*.

Saropoda bombiformis *Smith.* Victoria; 2♂ (Am. Mus. Nat. Hist. 295).

Anthophora wallacei sp. nov.

♀. Length about 14 mm.; expanse of wings about 27. Robust, black, with rather pale fuliginous wings; *hair of cheeks and occiput dense and white; front and face with long black bristles;* white hair at sides of face and around antennæ; clypeus

coarsely and densely rugoso-punctate, its anterior margin, and a median streak at right angles with it, dull cream-color; a small triangular creamy supraclypeal mark; a round spot of the same color at each lower lateral corner of clypeus (joining marginal band), and a small mark by each lateral suture; base of mandibles with a large light spot; labrum light, with the edge dark, and a dark spot at apex and one at each basal corner, the light part with numerous fuscous bristles; maxillary palpi 6-jointed, the second nearly as long as the following four together, broad, curved, its inner edge very finely and regularly ciliate, its outer with coarse black or fuscous bristles; third joint only about half as broad as second, but much broader than any of the following; fourth a little shorter than third; fifth shorter still; sixth minute; paraglossæ reaching beyond middle of labial palpi; tongue very long; antennæ short, entirely dark; *hair of thorax very dark brown, at first sight appearing black, but white, in strong contrast, on the metathorax and extending as far forward as the scutellum,* though on the latter strongly intermixed with dark; anterior middle of mesothorax also with some white hair; tegulæ dark rufo-piceous; legs with dark hair, white on outer side of the tibiæ; hind tibiæ and tarsi flattened, *basal joint of latter broad, entirely dark-haired;* spurs of hind and middle tibiæ very large; abdomen black, black-haired, *segments* 3 *and* 4 *each with a very conspicuous band of white hair.*

Hab.— Amboina (Am. Mus. Nat. Hist.).

Named after Dr. A. R. Wallace, in remembrance of his visit to Amboina.

Very much like *A. sesquicincta* (Erichson), but larger, and differing in the details of the pubescence. *A. sesquicincta* is generally known as *A. bicincta=Apis bicincta* Fabr. 1793, not of Schrank, 1781.

Anthophora æruginosa *Smith.* New South Wales, two (Am. Mus. N. H. 296).

Anthophora zonata (L.). Cochin China (Am. Mus. N. H. 415).

Anthophora vigilans *Smith.* Amboina (Am. Mus. N. H. 403). Dours gives entirely wrong measurements for this species, and places it as a variety or subspecies of *A. zonata,* while at the same time remarking that he has never seen it. It is entirely distinct from *A. zonata,* though somewhat related.

Anthophora elegans *Smith.* Amboina (Amer. Mus. N. H.). ♀. There are light hairs among the black on the head and thorax, and the hair of the cheeks is dull white; the red hair of the posterior tibiæ extends to cover most of the outer side of the basal joint of their tarsi. The species is a very striking one and the Amboina specimen looks just like Smith's types from Key Island, which I saw in the British Museum.

Anthophora pulchra *Smith.* Queensland and New South Wales (Am. Mus. H. H., 297). The hair of the thorax above is strongly intermixed with black, a fact not indicated by Smith. I do not know how this insect is to be separated from *A. zonata subcærulea* (Lep.), but I have no Indian specimens of the latter to compare; if, as I believe, there is no essential differences, *subcærulea* has priority. In general appearance, the insect is exactly like the African *A. circulata* (Fabr.).

Xylocopa tenuiscapa *Westw.* Madras. ♀.

Xylocopa latipes (*Drury*). Sumatra (R. Weber). ♂.

Xylocopa fenestrata (*Fabr.*). Madras, ♀. This is *fenestrata* as understood by Pérez; it does not wholly accord with the description of Bingham; thus, the hair at the apex of the abdomen is all black.

Xylocopa verticalis *Lepel.* N. India. ♂. This is evidently very close to *X. confusa* Pérez.

Xylocopa dissimilis *Lepel.* China. ♀.

Xylocopa bryorum (*Fabr.*). ♀. North Queensland. ♂. New South Wales. In Ann. Mag. Nat. Hist., Aug. 1905, p. 224, I regarded the Australian insect as belonging to a subspecies *dimidiata* Lep. This now appears to be an error, and I believe *dimidiata* is after all a valid species, not found in Australia.

Xylocopa mohnikei sp. nov.

♀. Length 20½ mm.; expanse 42 mm.; black, the thorax with bright yellow hair. Superficially, this is exactly like *X. bryorum*, but it differs as follows: Wings not so dark, nor so strongly tinted with green; first transverso-cubital nervure entire; base of first submarginal cell if anything a trifle *shorter* than that of second; face conspicuously narrower; clypeus with no median keel; upper two-thirds of pleura covered with yellow hair; basal segment of abdomen above with *very sparse* yellow hair, hardly apparent without a lens; median groove of mesothorax weaker. The face, cheeks and anterior tibiæ behind have dull white hair, on face mixed with black, as is also the yellow of the vertex.

Hab.— Amboina.

X. dimidiata Lep. is from Timor; *X. aruana* Rits. is considered to be the same. *X. mohnikei* differs from *dimidata* by having the flagellum ferruginous beneath except at base, the yellow hair on first abdominal segment very scanty, the hair at apex of abdomen all black, the hair on anterior tibiæ behind dull white instead of yellow, and presumably in the structural characters cited above, those of *dimidiata* being supposed to be essentially as in *bryorum*. From *X. confusa* Perez, the new species differs by the absence of a clypeal keel and the proportions of the submarginal cells.

Named after Dr. Mohnike, the Amboina entomologist (*cf.* Wallace, Malay Archipelago, p. 224).

Xylocopa dimidiata Smith, Trans. Ent. Soc. Lond., 1874, p. 287, from Ega on the Amazons, may take the name **X. batesi**, n. n.

Xylocopa chionothorax sp. nov.

♀. Length about 21 mm.; expanse 47½; width of abdomen 10. Black, of the general form of *X. dissimilis*, but smaller, the wings not so dark, and the thorax

above covered with white hair. Hair of head mixed fuscous and dull white; of sides and under part of thorax dark fuscous, except a large white patch beneath the wings; of basin of first abdominal segment rufo-fuscous; apical fringe black, and no light hair on abdomen; hair of legs brown-black; head large, face broad; space between lateral ocelli scarcely or not over half distance from either to eye; vertex dullish, with very few large punctures; area between antennæ convex, but not keeled; scape long, somewhat flattened but not dilated, with a little red at apex and base; flagellum reddish beneath; clypeus densely punctured, with a well-marked smooth median band; labrum with a median tubercle; maxillæ conspicuously marked with red at base and apex; middle of mesothorax smooth and impunctate; wings fuscous, with a strong purple (rosy-purple) iridescence; submarginal cells complete, the second a trifle longer below than first; posterior tibiæ with a raised line or keel from near the base to a short distance before the middle its end curved outward; in a strong light the hair on under side of hind legs appears dark reddish; scutellum and postscutellum transversely keeled; abdomen with numerous strong punctures; hind margins of ventral segments narrowly reddened.

Hab.— China (Am. Mus. Nat. Hist. No. 156).

In Bingham's arrangement of the Indian species, this falls next to *X. collaris*, but it is known at once from that by the white hair covering the thorax above except a small space in the middle. In size and shape, it resembles *X. fenestrata*; the coloration is much more like that of *X. phalothorax* Lep., from Sumatra.

Lestis bombylans (*Fabr.*). Both sexes from New South Wales. My material of *L. ærata* Smith is from Queensland.

Apis dorsata *Fabr.* Amboina. (Am. Mus. N. H.) This is typical *dorsata*: *Apis binghami* Ckll. (*zonata* Smith), appears to be a distinct species, as Ashmead states. I have it from the Khasia Hills, India (*Sladen*).

Apis indica *Fabr.* North India. The specimens have the abdomen banded as in var. *nigrocincta* Smith, but the apical segments and legs are dark. I have very similar specimens from Ceylon (Green).

Amboina, two specimens. I had hoped that I could identify these with *A. gronovii*, but they certainly are *A. indica*, and do not accord well with the description of Le Guillou's species.

Paracolletes venustus *Smith.* Victoria (Edwards). Previously known from S. Australia.

Paracolletes frederici *Ckll.* N. S. Wales. (Am. Mus. N. H. 305.) The specimen is a female; only the male has been known hitherto. It agrees in general with the male; length about 13 mm.; scape black; flagellum red beneath except at apex; apical fimbria of abdomen pale; hind femora and tibiæ with a very copious creamy-white plumose scopa, a tuft at the apex of the femora, and a suffused band down the tibiæ above, of fuscous hair; hind spur pectinate with numerous fine and quite long teeth. On both sides, the lower third of the first transverso-cubital nervure is wanting.

Paracolletes crassipes *Smith.* N. S. Wales. 2 ♀. (Am. Mus. N. H. 306.) Previously known from Swan River.

Paracolletes cupreus semipurpureus *Ckll.* New South Wales. Previously known only from Queensland. The specimen has only the apical part of the flagellum distinctly red. The abdomen of a second specimen is dark green with only a little crimson.

Paracolletes carinatulus *Ckll.* New South Wales. A female, nearly 11 mm. long, is referred with little hesitation to this species, known hitherto only from a male obtained in Queensland. It is close to *P. carinatus*, Smith, but differs by the hair of the legs being yellowish white, except a broad fuscous band on outer side of hind tibiæ, a fuscous band on outer side of middle tibiæ, and the hair on middle and hind basitarsi within a sort of pale orange. The long fringes of hair on margins of ventral abdominal segments 2 to 4 are white. The abdomen is olive green, with purplish tints. The upper edges of the clypeus shows beautiful crimson and purple tints. This insect is allied to *P. cupreus semipurpureus*, but larger, with black (not largely red) legs.

Euryglossa ephippiata *Smith.* N. S. Wales (*Edwards*). Previously known from Adelaide and Queensland.

Euryglossa fasciatella sp. nov.

♀. Length nearly 8 mm.; expanse just over 13 mm.; superficial appearance exactly like the European *Halictus fasciatellus*, except for the dark stigma. Black; with dull white pubescence; clypeus shining, with strong scattered punctures, and no keel; mandibles dark red at apex; antennæ black; vertex and mesothorax dull, minutely granular; scutellum shining though granular, with scattered punctures; metathorax minutely granular, dullish; tegulæ testaceous; wings yellowish; stigma large, dark reddish; nervures testaceous; second s. m. below a little more than half as long as first, receiving first r. n. a trifle nearer base than second to apex; b. n. falling short of t. m.; legs black, knees dark reddish, tarsi somewhat reddened, but not pale or red; abdomen broad, somewhat shining, reddish-black, the narrow hind margins of the segments testaceous.

Hab.— South Australia (Edwards coll.; Amer. Mus. Nat. Hist.).

Distinguished from *E. halictiformis* Sm. by the larger size, color of the legs, etc.

Euryglossa edwardsii sp. nov.

♀. Length about 7½ mm., expanse about 13; head and thorax black, without any metallic lustre; head large and round; face and cheeks with soft dull-white hair; labrum with a transverse shining groove; mandibles dark red except at apex; clypeus broad and flattened, shining, with strong scattered punctures, and no trace of a longitudinal keel; front dull, minutely striato-punctate; facial foveæ long and

linear; vertex dullish and punctured; ocelli in a curve; antennæ ferruginous, stained a little with fuscous above; thorax with very little hair; mesothorax shining, very sparsely punctured; area of metathorax smooth and shining; tegulæ black; wings yellowish, nervures and stigma ferruginous, venation normal; legs red, the femora darkest, the anterior femora strongly blackened behind, middle and hind tibiæ and tarsi light yellowish-red; hind spur pectinate with three long teeth, and one or two others rudimentary; abdomen broad, entirely dark ferruginous, with a silky gloss, apex with dull white hair.

Hab.— New South Wales (Am. Mus. Nat. Hist., 324).

Looks like a *Parasphecodes*; it is allied to *Euryglossa simillima* Sm., but differs by the red legs, entirely red abdomen, etc.

Goniocolletes gen. nov.

♂. Colletiform, hairy, with a rather narrow tapering abdomen; mandibles slender, with a short inner tooth; tongue very small; labial palpi 4-jointed, the joints subequal, the second and third shorter than the first or fourth, the first two joints broad apically, the last two very slender throughout; maxillary palpi ordinary, six-jointed; antennæ ordinary, the last joint flattened apically; stigma small and narrow; three submarginal cells, the first below about as long as the other two combined, the third larger than the second; second s. m. receiving first r. n. at its middle, third receiving second r. n. very near its end; second s. m. broad, moderately narrowed above; marginal cell with the apex rounded, not on costa; b. n. meeting t. m., or falling a little on the outer side; second r. n. with its upper part gently curved outwards; seventh dorsal abdominal segment presenting a roughened black triangular pygidial area, sharply pointed apically; apical ventral plate projecting far beyond dorsal, pygidiiform, narrow, rounded apically, dull and roughened except apically, where it is shiny, fringed laterally with very long curved pale hairs, and beneath with an erect median fringe of dark curved hairs; penultimate ventral segment shining and sparsely punctured, elevated in the middle and keeled, presenting a beak-like appearance in lateral view; remaining ventral segments normal; area of metathorax transversely grooved; legs slender, very peculiar; anterior tarsi with the first joint narrow, pale and flat, more than twice as long as the rest of the tarsus; middle coxæ with a keel-like protuberance beneath; middle femora with the lower half beneath excavated, as though a large piece had been bitten out, the basal end of the excavation furnished with a large tooth, directed apicad; middle tarsi long, pale and slender, the first joint concave beneath, and about twice as long as the rest of the tarsus; hind coxæ with a large protuberance beneath; hind tibiæ strongly bent; only one spur visible on hind tibiæ, and that small and pale; hind tarsi long and slender, basal joint with a tooth-like prominence beneath, basal joint not nearly as long as the remaining joints together; claws with a strongly divergent inner tooth. Type *G. morsus*, sp. nov.

Goniocolletes morsus sp. nov.

♂. Length about 13 mm.; black, clothed with long light yellow hair, dense and golden on the face; face broad; lower edge of clypeus broadly whitish; mandibles yellowish-white except the dark apex; scape black; flagellum red; blackish

above at base; mesothorax shining, strongly and closely punctured, except an area in the middle, where the punctures are very sparse; scutellum similarly punctured; sides of metathorax coarsely roughened or very densely punctured, yet shining; area triangular, transversely rather irregularly grooved; tegulæ pale yellowish; wings yellowish, nervures and stigma ferruginous; tarsi pale pellucid yellowish; tibiæ suffused and stained with rufo-fuscous; femora marked much like tibiæ, but anterior and middle femora entirely pallid above; abdomen black and densely punctured, except the very broad hind margins of the segments, which are pellucid shining testaceous; on the sixth segment above the long hair is fuscous, but on the first to fifth pale yellow.

Hab.— New South Wales (Amer. Mus. Nat. Hist., 304).

Lamprocolletes ruficornis, Smith, from Western Australia, shows several points of similarity, and may prove to be congeneric. It is not yet known in the male.

Crocisa quadrimaculata *Rads.* New South Wales (Am. Mus. N. Hist. 317). So far as I can make out from the description, this must be *quadrimaculata*, which is not a synonym of *C. albomaculata* Sm., as Friese has placed it — though with a query.

Crocisa macleayi sp. nov.

♀. Length a little over 14 mm.; black, the light markings (of pubescence) white stained with ferruginous; eyes converging below; mandibles somewhat elbowed, and with a spot of white hair at base; labrum with a low prominence on each side; clypeus rough with very dense small punctures, and with a smooth median line on its apical third; antennæ black; thorax with the usual spots; pleura light haired, with two bare black spots, one above and the other below; scutellum black, the margin w-like, the points very sharp, reddish-white hair coming from beneath the middle incision; tegulæ black; anterior wings very dark fuliginous, except the base (much less than half) and the usual spots, which are hyaline; marginal cell very short; tibiæ and basal joint of tarsi light-haired on outer side; first four abdominal segments with two spots on each side; first also with white shoulder-spots; inner spots on second segment transversely elongated, approaching the outer, which are hardly to be seen from above; fifth segment with one spot on each side; pygidial plate very narrow, with a strong median keel, and somewhat elevated cariniform margins, ventral segments two to four with a transverse spot on each side.

Hab.— New South Wales (Am. Mus. Nat. Hist., 317 pars.).

This looks at first sight like *quadrimaculata*, but it is much larger (♀ *quadrimaculata* is 11 mm. long) and the scutellum is quite different.

The following table separates the white-spotted Australian species of *Crocisa*:—

Length 11–12 mm.; second abdominal segment with an interrupted white band; scutellum W-like . . . . *C. rotundata* Friese (*albomaculata* Smith).
Second abdominal segment with four spots 1

1. Middle and hind tibiæ white only at base; size large . *C. lugubris* Smith.
   Middle and hind tibiæ covered with white hair on outer side 2
2. Larger, scutellum W-like . . . . . *C. macleayi* Ckll.
   Smaller, scutellum ⁓ -like . . . . *C. quadrimaculata* Rads.

C. albomaculata Smith is preoccupied by *C. albomaculata* (DeGeer) from Africa. *C. australensis* Rads., which Friese gives as a synonym, is an entirely different, *blue-spotted*, species, and *C. quadrimaculata* is also distinct. The latter, however, is perhaps what Friese took for *albomaculata*, and I believe that *rotundata* Friese is Smith's species. Smith expressly says, "scutellum deeply notched."

C. australensis is evidently very close to *C. lamprosoma* Boisd., and is perhaps not to be separated from it.

Crocisa cæruleifrons *W. F. Kirby.* New South Wales. (Am. Mus. Nat. Hist. 316.)

Crocisa nitidula (*Fabricius*). Amboina, ♀ (Am. Mus. Nat. Hist.). This species was originally described from Amboina, and the specimen agrees exactly with the Fabrician diagnosis. The tarsi are wholly without light hair, and the insect is 10 mm. long or a little more, so that it agrees with Friese's brief account of his *C. nitidula tarsalis*. The scutellum, however (wholly without dark marks, or hairs protruding from beneath) is rather of the ⁓-type, certainly not a good W. The greenish-blue spots shine most brilliantly.

The *C. nitidula* of Lepeletier has a blue-spotted scutellum, and a spot on each side of the first abdominal segment, instead of a broad entire basal band. It cannot possibly be reconciled with the Fabrician insect. *C. emarginata* Lep., from New Ireland, is evidently close to the true *nitidula*, though apparently distinct; this is not the *emarginata* of Friese. The *Crocisa nitidula* of Friese, Zeits. Hym. Dipt., 1905, p. 4, may take the name **Crocisa pernitida**.

Crocisa novæ-hollandiæ *Lepeletier.* Amboina (Am. Mus. Nat. Hist.). A lovely species, with the light markings pale dull blue; the first abdominal segment forms a very wide W, the points forming angles slightly greater than right angles. The scutellum is all black, but the axillæ have small blue spots. The insect agrees so well with Lepcletier's description that I cannot refuse to identify it with his species; I suspect that the original locality, "Nouvelle-Hollande," may be erroneous, as no such species has been found recently in Australia, and the type was from the Dejean collection, which I have on other occasions suspected to be fallible in the matter of locality-labels.

Nomia australica *Smith.* New South Wales; both sexes.

Nomia amboinensis sp. nov.

♀. Length 11½ mm.; expanse 20 mm.; a black, *Andrena*-like species with a shining nude bandless abdomen, covered at the extreme apex only with light yellowish hair. Sides of face with black hair, a little reddish near antennæ; front with punctures of two sizes; just above the clypeus is a delicately striated punctureless area; vertex with black hair; antennæ dark, flagellum faintly reddish beneath; clypeus coarsely striatopunctate, with a strong median keel and sharp raised lateral and apical margins; mandibles obscurely bifid; second joint of maxillary palpi about or nearly as long as 3 + 4; thorax above dull and granular, with very minute punctures, and scattered larger ones; hair of thorax short and black, paler on tubercles, dull white and copious on sides of metathorax; postscutellum with a large bifid prominence, the forks blunt; tegulæ large, dark coppery-red; wings very yellow; stigma and nervures clear ferruginous; second s. m. higher than broad, receiving first r. n. beyond its middle; legs black, hind tibiæ and tarsi more or less reddish; hair of anterior legs dark; of middle legs beneath fulvous, but yellowish-white on upper (outer) side of their tarsi and extreme apex of tibiæ; hind femora with a large curled dull white scopa; hind tibiæ and tarsi with much dull white hair; hind basitarsus large; abdomen with only the basal part of the segments punctured, and that not densely; base of fourth segment with long black hairs, prone and directed caudad; hind margins of ventral segments fulvous, and fringed with light hair.

Hab— Amboina (Am. Mus. Nat. Hist.).

Readily known from *N. dentata* Smith, of the Aru Is., by the black hair of face, and bifid postscutellar prominence. The scutellum is normal, a little depressed in the middle. If we admit *Hoplonomia, Paranomia* and *Stictonomia* as genera, this species might be regarded as the type of a new genus; but it is questionable whether so many genera should be recognized at the expense of the old *Nomia.*

Parasphecodes tilachus *Smith.* New South Wales. (Amer. Mus. Nat. Hist.) Previously known from Tasmania.

Parasphecodes tilachiformis sp. nov.

♀. Length 8 mm. or slightly more; head and thorax black, as also legs; abdomen dark red, strongly blackened from the third segment (except its basal third) to the apex; clypeus shining, with large punctures; antennæ wholly dark, the flagellum very faintly reddish beneath apically; hair of head and thorax dull white, abundant on pleura, scutellum and sides of metathorax; mesothorax dull and granular; area of metathorax strongly longitudinally plicate, without a very distinct rim; tegulæ black with a slight red tint; wings smoky, especially at apex, but not especially yellowish; stigma dark ferruginous; nervures fuscous; second s. m. much smaller than third, and conspicuously higher than broad, receiving first r. n. in its apical corner; legs with abundant short dull white hair; spurs ferruginous, hind spur simple; abdomen robust, dullish, with much short dull whitish hair, black on the black areas; venter with coarse dull white hair, which appears to have carried some pollen. In my table of *Parasphecodes* (Am. Mag. Nat. Hist., Sept. 1904) this runs

out, because the first r. n. does not meet second t. c., and the abdomen is not bright red. Putting aside the slight difference in venation, *P. tilachiformis* would run to *P. tilachus*, except that the ridge behind area is not very prominent, and the outer nervures are little weakened. The abdomen is much darker than in *tilachus*, with much more abundant though prevailingly shorter hair; the tegulæ and flagellum are also darker, as also is the stigma. There are no lateral hair-patches on the abdomen.

Hab.— New South Wales (Amer. Mus. Nat. Hist., 322).

Parasphecodes froggatti *Ckll.* New South Wales; two males. The antennæ (which were broken in the type) are very long, with the flagellum entirely black, varying to dull ferruginous beneath.

Binghamiella (gen. nov.) **antipodes** (*Smith*).

♀. Superficially like *Sphecodes*; but basal nervure only gently curved; second submarginal cell very broad, receiving the first recurrent nervure about its middle, its breadth below twice as great as that above; basal nervure meeting transverso-medial, which is very oblique; stigma large; mandibles tridentate; spurs yellowish white, hind spur simple; face and clypeus shining, with very large punctures; scutellum with very large punctures; area of metathorax distinct, longitudinally plicate; each side of metathorax with two dentiform angles; abdomen shining, sparsely punctured; scopa of hind legs white and silky; apex of abdomen with a small shining pygidial plate; venter hairy.

In Ashmead's tables this runs to *Callomelitta*, which is, however, very different in appearance, and would not at first sight be associated with it. Colonel Bingham, who kindly examined Smith's type of *Sphecodes antipodes* for me, wrote that it was not a *Sphecodes*, but should be placed in a distinct genus close to *Callomelitta* but differing in the shape of thorax, pubescence on hind tibiæ, etc. It is possible that *Binghamiella* should be considered only a subgenus of *Callomelitta*, but I think Col. Bingham is correct in regarding it as a distinct genus.

The specimen in Amer. Mus. N. H. (No. 323) is from New South Wales.

I have given an account of *Callomelitta* in Trans. Amer. Ent. Soc., XXXI, p. 318.

Prosopis elegans *Smith.* New South Wales. Previously known from Adelaide. It is allied to *P. sydneyana* Ckll., but larger, length about 9 mm. (♀).

Prosopis rotundiceps *Smith.* New South Wales; both sexes. Previously only known in the ♀, from Melbourne. The male, except for its larger size, agrees with the insect described as the ♀ of *P. metallica* Smith. The clypeus is yellow with the lower edge black, and the large semilunar lateral marks reach the level of the antennæ. There is no supraclypeal mark. The sides of the scutellum and postscutellum are black. The ven-

tral surface of the abdomen is without tubercles. The female has a small supraclypeal mark, not mentioned by Smith. Judging by the description, I cannot help suspecting that *P. obtusata*, Smith, is a variety of *rotundiceps*.

Prosopis alcyonea *Erichs.* New South Wales; both sexes. By the structure of the third abdominal segment in the male, this species, with *P. bidentata*, Smith, and *P. bituberculata*, Smith, form a little group. Erichson described only the female of *P. alcyonea*.

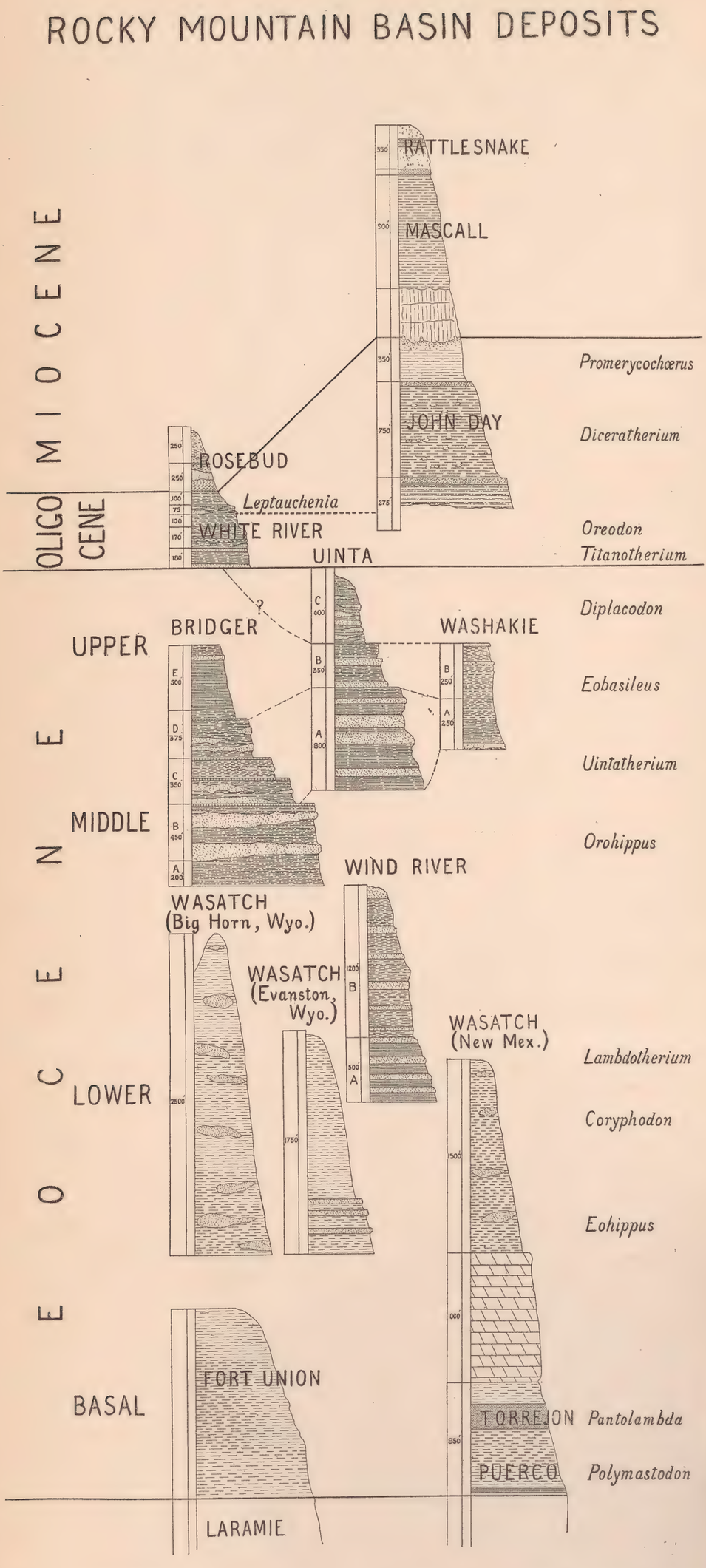

Fig. 1.—COMPOSITE SECTION OF THE EOCENE AND OLIGOCENE

Net Thickness of Eocene, 7200 ft.

56.9(118:7)

Article XI.— TERTIARY MAMMAL HORIZONS OF NORTH AMERICA.

Abstract of a Preliminary Study.[1]

By Henry Fairfield Osborn.

It appears wise to publish a preliminary outline of a fuller discussion of this subject. This outline is accompanied by some geological observations on the section between northwestern Nebraska and the Black Hills, and by preliminary Eocene–Pleistocene correlations (Figs. 1–3).

The chief authorities are:

Osborn, Correlation Papers (1899–1900).[2]

Matthew, Classification of the Freshwater Tertiary (1899).[3]

Depéret, L' évolution des Mammifères tertiaires (1905).[4]

Among earlier contributors are Hayden, Leidy, Marsh, Cope, King, Scott, and Osborn; among more recent contributors are Peall, Merrill, Matthew, Hatcher, Wortman, Darton, J. C. Merriam, Peterson, Douglass, Gidley, Granger, Sinclair, Loomis. Full acknowledgments will be made in the final paper. Chief acknowledgment is due here to Messrs. Matthew and Granger.

1. EOCENE CORRELATED SECTIONS.

The accompanying Eocene correlation (Fig. 1), chiefly the work of the writer, with the assistance of Mr. Walter Granger, is explained as follows:

(1) The combination of various Eocene sections by Hayden, Wheeler, Cope, King, Wortman, Matthew, Granger, Veatch, Osborn, in the Rocky Mountain basins gives us a total thickness of 7200 feet. (2) The only section based on a careful survey is the Bridger; the Bridger deposits prove to be largely wind- and partly water-borne volcanic materials (Sinclair), and this is probably true of other Eocene deposits. (3) The formation names are all geographical. (4) The chronological correlation of the sections is entirely faunistic or based upon our present knowledge of the

[1] Originally prepared as an address before the International Geological Congress, City of Mexico, 1906 (not delivered). Abstract presented before the National Academy of Sciences, Boston, Thursday, November 22, 1906; also before the Society of Palæontologists, New York, December 27, 1906. To be published in full in the Bulletin of the U. S. Geological Survey.

[2] Ann. N. Y. Acad. Sci., Vol. XIII, 1900, pp. 1–72.

[3] Bull. Amer. Mus. Nat. Hist., Vol. XII, 1899, pp. 19–77.

[4] Comptes rendus, Acad. Sci. Paris, 1905–1906.

existing stratigraphic position of characteristic mammals; to these faunal levels in different formations the faunistic names Polymastodon Pantolambda, Coryphodon Beds, etc., some new, some already in use, are applied. (5) The sections and correlations are to be considered as of a preliminary and provisional character.

2. OLIGOCENE AND LOWER MIOCENE.

Geological Notes by the Writer (1906), *South Dakota and Northwest Nebraska.*

Fig. 2 is a graphic interpretation of the wonderful deposits of the Big Bad Lands, and represents an idealized view looking southeast from the Cheyenne River (South Dakota), over the rising levels of the Oligocene, beyond and across the White river, through the Lower Miocene, to the summit of Porcupine Butte, a conspicuous land mark which caps the Upper Rosebud on Porcupine Creek, a southern tributary of the White River.

The present interpretation[1] of this continuous Oligocene and Lower Miocene section is to divide the deposits into two contemporaneous series, namely: (1) River and channel deposits, (2) overflow finer deposits, as follows:

	A. River and channel deposits: sandstones and conglomerates.	B. Overflow deposits: fine sandstones, clays, volcanic ash.
Lower Miocene	Gering Sands and Conglomerates.	Rosebud.
Upper Oligocene	Protoceras Sandstones.	Leptauchenia, or upper Brulé.
Middle Oligocene	Metamynodon Sandstones.	Oreodon or Lower Brulé.
Lower Oligocene	Titanotherium Sandstones.	Chadron Formation.

These old river channels vary from some hundreds of feet to more than a mile in width.

3. Volcanic ash layers occur extensively in the Mountain basin deposits and as thinner layers in many of the Plains deposits.

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[1] This interpretation represents the thought of several observers, especially of Matthew, Hatcher, Scott and Osborn.

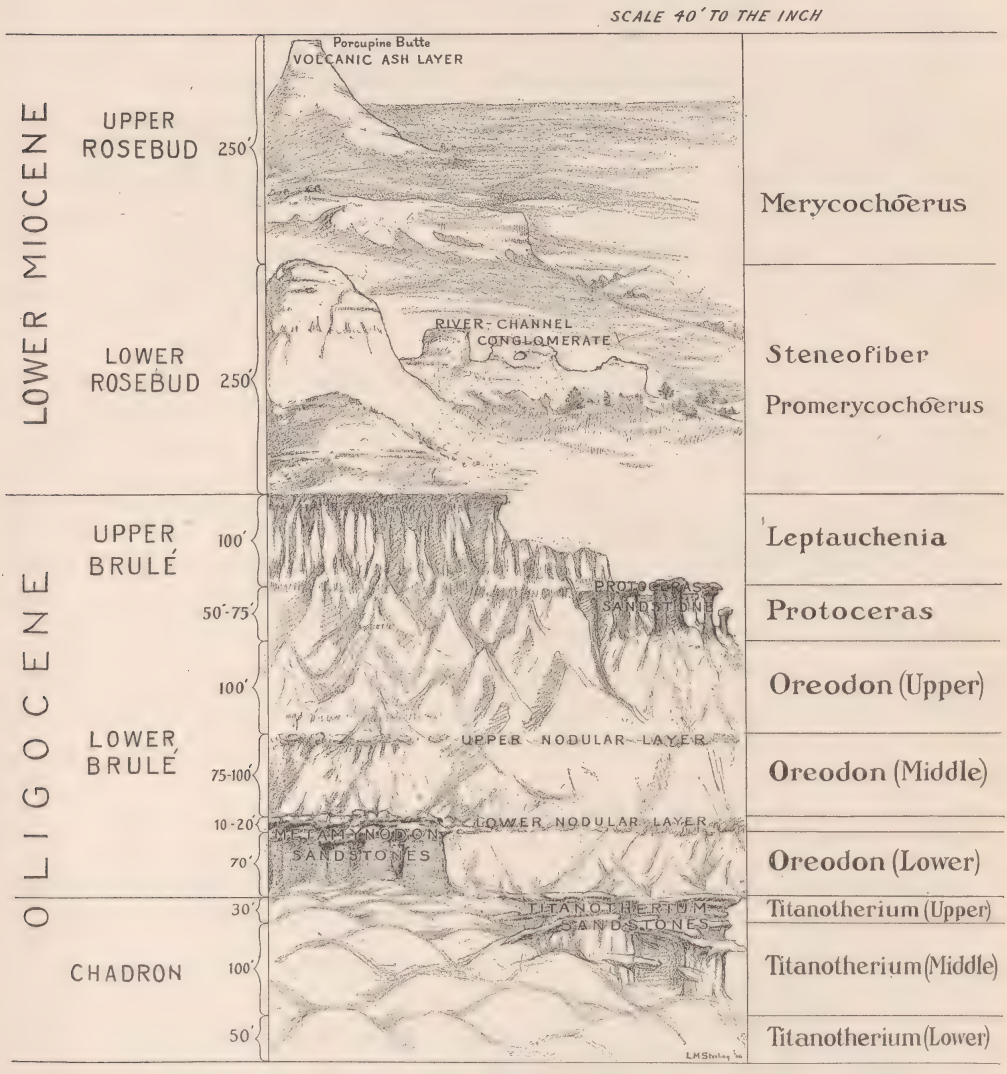

Fig. 2. Idealized birds-eye view of the great Badlands of South Dakota, looking southeast across the Cheyenne and White Rivers to Porcupine Butte, on Porcupine Creek, Pine Ridge Reservation, South Dakota.

Ancient river channels, Titanotherium Sandstones, Metamynodon Sandstones, Protoceras Sandstones, river channel conglomerates.

Clays and sandstones of the Titanotherium region, Leptauchenia and Rosebud beds.

EOCENE.

I. First faunal phase, basal eocene. Archaic mesozoic mammals with partly south american, partly european affinities.

POSTCRETACEOUS OR BASAL EOCENE.

1. Puerco Formation. Polymastodon Beds.

Homotaxis. North America: Puerco Formation (500 feet) San Juan Basin, New Mexico; a portion of the Fort Union Formation, Montana. S. America: A contemporary or previous (Cretaceous) land connection with South America is indicated by similar mammals occurring in the Notostylops Beds,[1] Upper Cretaceous or Basal Eocene of Patagonia.

Summary:

Archaic Triassic mammals	4 genera	6 species
" Cretaceous "	15 "	30 "
	19 genera	36 species
Modernized or distinctively Tertiary mammals	00 "	00 "

ÉTAGE THANÉTIEN.

POSTCRETACEOUS OR BASAL EOCENE.

2. Torrejon Formation. Pantolambda Beds.

Homotaxis. North America: Torrejon Formation (300 feet), continuous with Puerco Formation, San Juan Basin, northwest New Mexico; a portion of the Fort Union Formation, Montana (Douglass,[2] Farr). Europe: Thanétien or Cernaysien.

Homotaxis with Europe is indicated by the common presence in France and North America of similar stages of Plagiaulacidæ, Arctocyonidæ, Mesonychidæ, (?) Triisodontidæ. Other identifications are very uncertain.

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[1] Closer comparison of the Puerco and Notostylops faunæ is very desirable. It appears probable that the affinities will prove to be very close.

[2] Douglass, Earl. 'A Cretaceous and Lower Tertiary Section in South Central Montana.' Proc. Amer. Phil. Soc., Vol. XLI, No. 170, pp. 207–224. Also 'New Vertebrates from the Montana Tertiary'. Ann. Carnegie Museum, Vol. II, No. 2, 1903, pp. 145–200.

Summary:

Archaic Triassic stock	4 genera	5 species
" Cretaceous "	21 "	45 "
Total	25 genera	50 species
Modernized Tertiary stock	1 genus	1 "

II. Second faunal phase, lower eocene. First modernization, invasion of the archaic by the modern fauna. South american land connection interrupted. Close faunal connection with western europe. Initial elimination of the archaic fauna in competition with the modern.

ÉTAGES SPARNACIEN, YPRÉSIEN.

LOWER EOCENE.

3. Wasatch Formation. Coryphodon Beds.

Homotaxis. North America: Wasatch Formation, in part (1750 feet), Evanston, western Wyoming, the typical horizon; San Juan (Formation) basin of northern New Mexico (1500 feet); in the Big Horn (Formation) basin of northern Wyoming (2500 feet); in the lower portion of the Huerfano Formation near Spanish Peaks, Colorado. S. America: No South American affinities are known. Europe: Strong affinities with the Étage Suessonien, or Étage Sparnacien and Étage Yprésien (Londinien) of France are found in the evolution of the archaic and in the migrations of the modern mammalia of this period.

Summary:

Triassic mammals	00 genera	00 species
Other archaic mammals	23 "	51 "
Modernized mammals	18 "	47 "

III. Third faunal phase, lower to upper eocene. Absence of fresh eurasiatic or northern migration. Continuation of similar environmental conditions. Descendants of the archaic and modernized mammals slowly evolving and competing with each other during the lower and middle eocene. Gradual elimination of the archaic mammals. Gradual divergence from the fauna of western europe, and little evidence of faunal interchange. Establishment of north american ungulata—artiodactyla.

LOWER EOCENE.

4. Wind River Formation. Lambdotherium and Bathyopsis Beds.[1]

HOMOTAXIS. NORTH AMERICA: Wind River Formation of Wyoming (1200–1400 feet); Lower Huerfano Formation of Colorado, in part (300 feet). EUROPE: provisional homotaxis, Lower Wind River=Yprésien of France, in part. Upper Wind River=Lutétien inférieur of France.

The balance is now for the first time in favor of the modernized mammals, as shown in the following summary:

Archaic or Cretaceous mammals	11 genera	22 species
Modernized or Tertiary "	18 "	30 "

Preliminary Faunal Divisions.

Lower Wind River, A, 500 feet, Red Beds, Lambdotherium Beds. Containing *Coryphodon, Phenacodus, Eohippus, Lambdotherium Bathyopsis,* etc.

Upper Wind River, B, 800 feet, Eotitanops Beds. Containing *Coryphodon, Phenacodus,* also *Eotitanops,* gen. nov. (*"Palæosyops"*) *borealis.* This stage approximates the Lutétien inférieur of France (Argenton, older Lissieu, older Egerkingen) and Bracklesham of England.

ÉTAGES LUTÉTIEN SUPÉRIEUR, BARTONIEN.

MIDDLE EOCENE.

5. Bridger Formation. Orohippus Beds. Uintatherium Beds.

HOMOTAXIS. NORTH AMERICA: Bridger Formation of western Wyoming (1800 feet), Lower Washakie Formation (250 feet) of Wyoming in part; Upper Huerfano Formation of Colorado, in part; Lower Uinta Formation of n. Utah (1150 feet), in part. EUROPE: provisional homotaxis, Lower Bridger=Lutétien supérieur. Calcaire grossier of Paris, Issel, of France. Buchsweiler. Later fissure deposits of Lissieu and Egerkingen. Upper Bridger=Bartonien (Calcaire de Saint Ouen, Grès de Cesséras) in part.

Fauna. The whole vertebrate fauna, reptilian and mammalian, of this period is the most completely known of that of any of the Eocene phases. The mammalian summary is as follows:

[1] Professor F. B. Loomis has recently (Dec. 1906) completed an accurate section of the Wasatch (Big Horn) and Wind River formations, which will be available for the final report.

Archaic Cretaceous mammals	15 genera	35 species
Modernized Tertiary "	57 "	146 "
	72 "	181 "

6. Washakie Formation. Uintatherium Beds, Eobasileus[1] Beds.

Homotaxis. North America: Lower Washakie Formation of E. Wyoming, equivalent to the Upper Bridger Formation and Lower Uinta Formation. Upper Washakie Formation, equivalent to Middle Uinta Formation. Europe: Bartonien of France.

The mammalian fauna of this stage, which has long been recognized (Osborn, 1880) as in general intermediate between the Bridger and Uinta, is sparsely known. The American Museum expedition (Osborn, Granger, 1906), has very precisely fixed its age as follows:

Faunal Divisions.

B. Upper Washakie. Eobasileus Beds.

Grey and Green Beds (250 feet), Haystack Mountain, containing *Loxolophodon*, ?*Tinoceras*, *Dolichorhinus cornutus*, Perissodactyla-Amynodontidæ, Artiodactyla-Elotheriidæ.

A. Lower Washakie. Uintatherium Beds.

Brown Beds, (250 feet). Containing *Uintatherium*. Among Perissodactyla, "*Telmatherium*" *megarhinum*. Equivalent to Upper Bridger: C, D, E.

ÉTAGES BARTONIEN, IN PART, LUDIEN (LIGURIEN), IN PART.

UPPER EOCENE AND LOWER OLIGOCENE.

7. Uinta Formation. Uintatherium Beds, Eobasileus Beds, Diplacodon Beds.

Homotaxis. North America: Lower Uinta Formation (800 feet), equivalent to Upper Bridger Formation and Lower Washakie Formation; Middle Uinta Formation (350 feet), equivalent to Upper Washakie Forma-

[1] The name *Loxolophodon* commonly applied by Cope and others to the Dinocerata of this stage is preoccupied for a Wasatch Coryphodont, *Loxolophodon semicinctus* Cope. *Tinoceras* is equally inapplicable because first applied to a Bridger Uintathere

tion. True or Upper Uinta Formation (600 feet), closely approaching if not equivalent to the lowermost levels of the White River Oligocene. EUROPE: homotaxis is now very difficult owing to the *absolute dissimilarity* of the European and North American faunæ in these stages. It is very important to note: (1) that in the Bartonien of France, which is reckoned as Upper Eocene but not the highest stage, there appear the families Artiodactyla-Anthracotheriidæ and Perissodactyla-Chalicotheriidæ; (2) that in the Ludien, which is reckoned as uppermost Eocene, there appear the families Marsupialia-Didelphyidæ, and Rodentia-Sciuridæ. All these four families are not known to occur in North America until the Lower Oligocene Plains Formation.

Its mammalian fauna is sparsely known, as follows:

Archaic Cretaceous mammals	4 genera	5 species
Modern or Tertiary mammals	25 "	37 "

Provisional Faunal Levels.

Upper Uinta,[1] C, 600 feet. Diplacodon Beds.
Distinguished by absence of Dinocerata. Presence of Canidæ.

Middle Uinta, B, 350 feet, Eobasileus Beds.
Containing ?Dinocerata, *Loxolophodon,* and especially *Dolichorhinus cornutus.* Creodonta-Mesonychidæ (last appearance). Equivalent to Upper Washakie, B.

Lower Uinta, A, 800 feet, Brown Beds. ?Uintatherium Beds.
?Equivalent to Upper Bridger, C, D, and to Lower Washakie, A.

Faunistic Separation from Western Europe in beginning of the Upper Eocene.

	Families Peculiar to Europe	Families common to W. Europe and N. America	Families Peculiar to N. America.
Amblypoda			1
Insectivora	?	?	1
Creodonta		1	2
Primates	2	0	2
Rodentia	1	0	1
Carnivora	0	1	0
Artiodactyla	6	0	4
Perissodactyla	1	2	3
Cheiroptera	1	?	?
	11	4	13

Thus in the Mountain Region Upper Eocene there are only 4 to 5 families in common with Europe, in a total of 28–30 families, whereas in the Oligocene Mountain, and, Plains regions (see p. 245) there are 21 families in common with Europe in a total of 48 families.

[1] Prof. Scott suggests that C, or Upper Uinta, should be placed in the Lower Oligocene. Peterson did not observe any nonconformity between C and B.

OLIGOCENE.

IV. The fourth mammalian phase, lower oligocene. Second modernization. First knowledge of the great plains fauna. Absence of all archaic mammals except hyænodontidæ. Reëstablishment of faunal resemblance with western europe.

North America.— A second modernization, as remarkable as the first or Wasatch modernization, is shown by the first appearance of 16 families of mammals which have not as yet been recognized certainly in the Mountain Eocene Basins, namely: 6 existing families of Rodents, 4 existing families of Carnivora, 4 existing families of Insectivora, 1 existing family of Perissodactyla, 1 now extinct European family of Artiodactyla.

Europe.— A very similar modernization occurred in western Europe.[1] In the Ludien (= Lower Oligocene Lapparent, = Uppermost Eocene Depéret), Sannoisien and Stampien (= Lower Oligocene), 17 modern or still existing families appear for the first time which have not been found in earlier geological stages. Of these new families 6 appeared simultaneously in North America.

	W. European families not found in North American Oligocene.	Families common to W. Europe and N. America by contemporaneous or previous migration.	N. American Families not found in W. European Oligocene.
Edentata	1	0	0
Rodentia	5	4	3
Insectivora	1	3	2
Creodonta	0	1	0
Marsupialia	0	1	0
Carnivora	3 (sub. fam.)	3	1
Artiodactyla	5	2	4
Perissodactyla	1	7[2]	1
	16	21	11

Thus: (1) The faunal community with western Europe becomes much closer than in the Upper Eocene (see p. 244). (2) The strongest community is among the Perissodactyla. (3) The least community is among the Artiodactyla.

[1] This generalization is based upon the faunal lists of Depéret (*op. cit.*, 1905).
[2] The Titanotheriidæ, found in central Europe, are included in this figure.

ÉTAGE SANNOISIEN (TONGRIEN INFÉRIEUR).

LOWER OLIGOCENE.

8. Chadron Formation. Titanotherium Beds.

HOMOTAXIS. NORTH AMERICA: Horizon A of Hayden and Leidy; Lower White River group, Chadron Formation (200 feet) (Darton); Titanotherium Beds (Hayden) of South Dakota and western Nebraska; Horsetail Creek Formation (Matthew) of northeast Colorado. Pipestone Creek Formation (Douglass) of Montana. Swift Current Creek, Cypress Hills, of British Columbia, etc. EUROPE, *provisional homotaxis*: Ludien, in part; Sannoisien (Tongrien Infér.); Stampien (Tongrien Supér).

ÉTAGE STAMPIEN (TONGRIEN SUPÉRIEUR).

MIDDLE OLIGOCENE, FIRST PHASE.

9. Lower Brulé Clays (Darton). Oreodon Beds, and Metamynodon Sandstones.

HOMOTAXIS. NORTH AMERICA: Horizons B and C of Hayden and Leidy; Lower Brulé Clays (Darton), Metamynodon Sandstones (Wortman);[1] with widespread similar exposures in northeast Colorado, Cedar Creek Beds, Matthew; in southeast Wyoming; in South Dakota; in northwest Nebraska. EUROPE. Approximate homotaxis with the Stampien or Oligocène Moyen of Europe is indicated by similar stages in the evolution of Artiodactyla-Anthracotheriidæ (*Hyopotamus*), of Perissodactyla-Amynodontidae (*e. g. Metamynodon, Cadurcotherium*), -Tapiridae, -Rhinocerotidae, -Chalicotheriidæ. Also by the disappearance in both countries of Perissodactyla-Amynodontidæ, Creodonta-Hyænodontidæ.

MIDDLE OLIGOCENE, SECOND PHASE.

10. Upper Brulé Clays. Leptauchenia Beds, and Protoceras Sandstones.

HOMOTAXIS. NORTH AMERICA: Upper White River Formation of South Dakota, Horizon C of the Hayden and Leidy Section; Brulé Clays (Upper part) Darton, 1897. Leptauchenia Beds (Wortman), and Protoceras Sandstones (Wortman). The sandstones contain the forest and fluviatile

[1] Wortman, J. L. On the divisions of the White River or Lower Miocene of Dakota. Bull. Amer. Mus. Nat. Hist., Vol. V, 1893, pp. 95–105.

fauna, the Leptauchenia Clays contain the plains fauna. Lower part of Cañon Formation (Matthew) of northeast Colorado. White Buttes (Martin) of North Dakota. Lower John Day Formation of Oregon (250–300 feet, tuffs).

ÉTAGE AQUITANIEN.

1. UPPER OLIGOCENE, FIRST PHASE.

Middle John Day Formation. Diceratherium Beds.

Homotaxis. America: Middle John Day Formation of Oregon (Diceratherium Beds Wortman), 500 to 1000 feet, typical mountain fauna. Europe: Aquitanien. Homotaxis with the Aquitanien of France, typified by the Saint Gérand-le-Puy (Allier, France) fauna, is close, as indicated by similar stages in the evolution of Perissodactyla-Tapiridæ, -Diceratheriinæ, -Aceratheriinæ, -Chalicotheriidæ, and other families.

Notes as to Transitional Upper Oligocene and Lower Miocene Formations.

1. The Upper John Day Formation or Promerychochœrus Beds of the Mountain Region of Oregon, and the Gering and Arikaree Formations (Darton) or Rosebud Formations (Matthew) of the Plains Region, northern Nebraska, may be regarded as transitional between the Oligocene and Miocene as these divisions are employed in France.[1] By analogy with Europe the older fauna of these beds is slightly subsequent to that of Saint-Gérand-le-Puy, that is, Upper Oligocene or Aquitanien, which, it is true, several authorities place in the Lower Miocene. The upper John Day of the Mountain Region is somewhat older than the Lower Rosebud of the Plains although both contain *Promerycochœrus*.

2. Recent explorations in the upper portion of the Harrison beds (Agate Spring Quarry, Peterson[2]) reveal a fauna which partly resembles that of the Upper Oligocene of France; at the same time it contains *Amphicyon*, a characteristic Miocene form. Until more exact comparisons can be made this fauna should be considered transitional from the Oligocene to the Lower Miocene inclusive.

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[1] Careful comparison of *Steneofiber* and other forms leads Matthew to the opinion that the Upper John Day is of *slightly* more recent age than St. Gérand-le-Puy.

[2] "From these discoveries it appears that the Miocene section from the Oligocene to the top of the Nebraska Beds, in this general locality, may perhaps have to be regarded as Lower Miocene." Peterson, "The Agate Spring Fossil Quarry," 1906, p. 491.

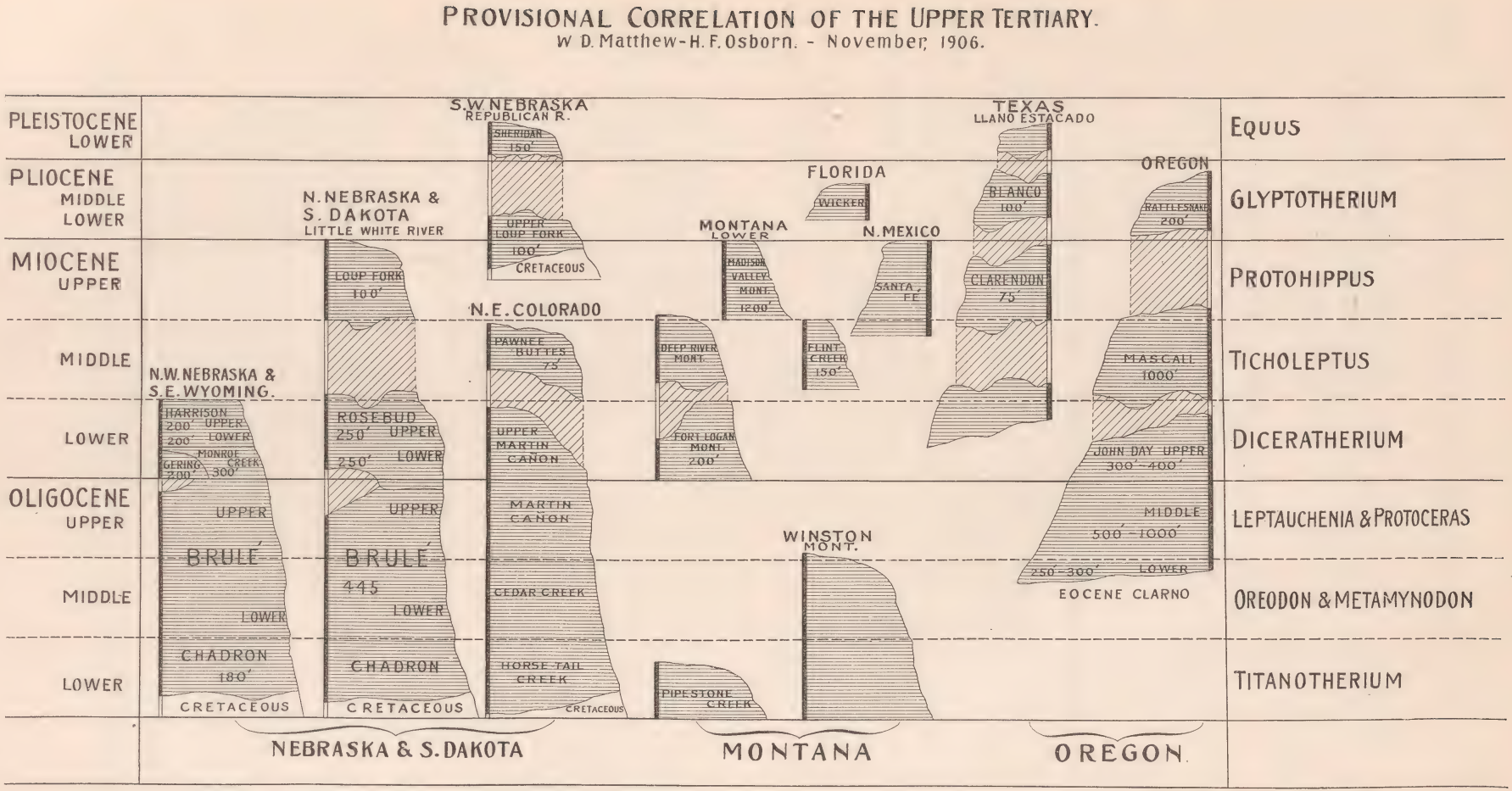

Fig. 3. Provisional correlation of the Upper Tertiary.
Under each column; the line separating the Upper Oligocene from the Lower Miocene is drawn provisionally. See p. 249.

MIOCENE.

ÉTAGES AQUITANIEN, LANGHIEN.

TRANSITION: UPPER OLIGOCENE AND LOWER MIOCENE.

Arikaree Formation. Promerycochœrus Beds.

HOMOTAXIS. AMERICA: EARLIER PHASE. Mountain Region, Upper John Day Formation of Oregon, Promerycochœrus Beds, Wortman, 300–400 feet of tuffs.

LATER PHASE. Great Plains, Horizon D, of Hayden and Leidy. Gering Formation (Darton, 1897), (= Lower levels, local, 200 feet). Arikaree Formation (Darton) (= Middle and Upper levels, 800 feet). Monroe Creek Formation (= lower Arikaree) and Harrison Formation (= upper Arikaree, Hatcher) of northwestern Nebraska and southwestern Wyoming. Rosebud Formation (Matthew) of southern South Dakota, Martin Cañon (upper levels) of northeastern Colorado (Matthew). Fort Logan Formation (or Lower Deep River) of Montana. Cañon Ferry Formation (Douglass) of Montana.

V. FIFTH FAUNAL PHASE. FRESH MIGRATIONS VIA EURASIA. FIRST APPEARANCE OF AFRICAN PROBOSCIDEA, OF TRUE FELINÆ AMONG THE FELIDÆ, OF SHORT-LIMBED TELEOCERINÆ AMONG RHINOCEROTOIDEA, OF CERVIDÆ, ANIMALS OCCURRING IN THE LOWER MIOCENE OF EUROPE. EVIDENCE OF INCREASING SUMMER DROUGHTS.

ÉTAGES LANGHIEN, HELVÉTIEN.

MIDDLE MIOCENE OR LOWER AND MIDDLE MIOCENE.

Upper Deep River Formation. Ticholeptus Beds.

HOMOTAXIS. AMERICA: CENTRAL PLAINS. Horizon E of Hayden and Leidy, 'Pawnee Creek' Formation (Matthew) of northeastern Colorado, 75 feet; immediately overlying the Harrison beds. ?Panhandle Formation Gidley) of northwestern Texas. NORTHERN PLAINS, Upper Deep River Formation (Smith Creek) or Ticholeptus Beds of Montana; Flint Creek Beds (150 feet) of Montana; Laramie Peak of Wyoming. MOUNTAIN

Region, Mascall Formation (1,000 feet) capping the Columbia lava (1000 feet) which in turn overlies the Upper John Day Formation (lower part). The Colorado (Matthew) and Montana (Scott, Douglass) fauna is closely similar.

ÉTAGE TORTONIEN.

UPPER MIOCENE.

Loup Fork Formation. Protohippus Beds.

Homotaxis. North America: Plains Region. The typical Loup Fork (of Hayden) of South Dakota and northwestern Nebraska, near Ft. Niobrara (100 feet) renamed 'Nebraska Formation' by Scott to distinguish it from other levels; Ogallala Formation (in part) Darton of Nebraska and South Dakota; Santa Fé Marls of New Mexico; Clarendon Beds (Cummins) Llano Estacado, northwestern Texas (75 feet). Northern Plains, Madison Valley Beds, Montana (120 feet). Europe: Tortonien, Grive-St.-Alban (Isère), Steinheim (Würt.). The Loup Fork mammals, although including *Hipparion*, are not quite so modernized as those of Eppelsheim and Pikermi which we regard as lower Pliocene.

PLIOCENE.

ÉTAGES MESSINIEN, PLAISANCIEN.

Homotaxis. Pliocene homotaxis must be prefaced by the statement that the fauna is very sparsely and imperfectly known as yet, and that correlations with Europe are very provisional. The gaps will undoubtedly be filled in eventually.

An early phase, which may be termed the 'Republican River Formation,' is provisionally and subject to further exploration distinguishable (Matthew) from the typical Loup Fork of Hayden, and presents certain parallels with the *Lower Pliocene* of Europe, if not of more recent age. It is with difficulty distinguishable from the Loup Fork, whereas it is widely separate from a second and much later phase, represented by the Blanco Beds of northwestern Texas, which is much more recent in its fauna.

LOWER PLIOCENE OR FIRST PHASE.

Republican River Formation. Peraceras Beds.

Homotaxis. America: Republican River Beds or "Upper" Loup Fork (100 feet); of northwestern Kansas Ogallala Formation (in part) Darton, of northern Nebraska; Archer Formation of Florida, in part, Rattlesnake Formation, John Day Valley, Oregon. Europe: Messinien, Eppelsheim in northern Europe; Pikermi in Greece. Mt. Léberon (Vaucluse).

VI. Sixth faunal phase, land connection with south america reëstablished. Invasion of south american edentata–gravigrada and –gylptodontia. Migration of north american mammals to south america.

The Blanco formation of Texas is decidedly distinct and more recent than the typical Loup Fork, the Republican River, or the Rattlesnake.

ÉTAGE ASTIEN.

MIDDLE PLIOCENE OR SECOND PHASE.

Blanco Formation. Glyptotherium Beds.

Homotaxis. North America: Plains Fauna, Blanco Formation (Cummins and Cope) 100 feet, Llano Estacado of Texas; Ogallala Formation (Darton) northwestern Nebraska (300 feet). Mountain Fauna, Rattlesnake Formation, John Day, Oregon (200 feet).

ÉTAGE SICILIEN.

UPPER PLIOCENE OR THIRD PHASE. unrecognized.

Elephas Beds?

In Europe the Uppermost Pliocene is distinguished by the disappearance of *Hipparion* and the advent of *Equus* (*E. stenonis*), also of *Elephas* (*E. meridionalis*).

This phase has not been recognized in America. It is probable, however, that certain levels in Texas, Nebraska and elsewhere, now classed as Lower

Pleistocene, and containing *Elephas imperator* (an animal analogous to *E. meridionalis*), as well as *Equus* will prove to represent the American Upper Pliocene.

VII. Seventh faunal phase, pleistocene. Increasing cold, moisture, and forestation. Third modernization by a gradual eurasiatic invasion of hardy, forest, fluviatile, mountain (alpine), plains, and barren-ground fauna. Gradual extinction of the larger ungulata, of the native north american stocks, of the south american invading stocks, of the miocene invading eurasiatic and african stocks.

PLEISTOCENE.

LOWER PLEISTOCENE. PRE-GLACIAL.

Our knowledge of the mammals in this period is still confined to the Western Plains and Mountains.

Sheridan Formation. Equus Beds.

Homotaxis. North America: *Plains and forest border fauna,* Sheridan Formation (Scott) or *Equus Beds,* Hay Springs, of northwestern Nebraska; Rock Creek Formation (Gidley) of Tule Cañon, Llano Estacado, Texas. Widely scattered and numerous deposits in Great Plains and Mountain Regions. Europe: Preglacial. Forest Beds of Norfolk (England); St. Prest (Eure-et-Loir); Durfort (Gard), containing *Elephas meridionalis* (last appearance). The European fauna of this period includes (Osborn, 1900): 12 Pliocene species, 32 Pleistocene species and races, now extinct, 17 living species, (7 Insectivora, 1 Cheiroptera).

EARLY PHASES OF THE MIDDLE PLEISTOCENE.

In the early or Glacial phases *Cervus* does not appear. The Camelidæ, Equidæ, Tapiridæ, Edentata-Gravigrada and Elephantidæ still survive. Extinct species of modern genera appear and many modern species appear.

The earliest phase, corresponding with the earliest mid-Pleistocene of Europe, is probably at present unrecognized in America.

LATE PHASES OF THE MIDDLE PLEISTOCENE.

HOMOTAXIS. AMERICA: Potter Creek Cave, Shasta County, California Silver Lake, Oregon.

Environmental conditions on the Pacific coast were different from those in the Middle and Eastern States: (1) All glaciation on the Pacific Coast was comparatively late in the Pleistocene and of the Alpine type (Sinclair). (2) It is quite possible therefore that many types of mammals (elephants, mastodons, camels, bisons) survived in the comparatively mild climate of the Pacific coast after they had become extinct in more easterly regions (Sinclair).

1. Potter Creek Cave. The very rich Potter Creek Cave fauna[1] is regarded by Merriam and Sinclair[2] as a late phase of the Middle Pleistocene, even as late as the last quarter of the Pleistocene. It contains 5 extinct genera and 52 species of which 21 are extinct and 21 are still existing. It is chiefly a forest fauna; forest types are numerous and plains types are lacking.

LATE PHASE OF MIDDLE PLEISTOCENE.

HOMOTAXIS. AMERICA: Port Kennedy Cave, Chester County, Pennsylvania.

The Port Kennedy Cave[3] contains 66 species, including 40 extinct species (fide Cope, Mercer).

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[1] Sinclair, Wm. J. A Preliminary Account of the Exploration of the Potter Creek Cave. Shasta County, California. Science, N. S., Vol. xvii, No. 435, May 1, 1903, pp. 708–712.

[2] 'The Exploration of the Potter Creek Cave.' Univ. of California Publications, Vol. II, No. 1, 1904.

[3] Mercer, H. C. 'The Bone Cave at Port Kennedy, Pennsylvania.' Jour. Acad. Nat. Sci Phila., Vol. XI, Pt. 2, 1899.

59.9, 61 E (119:77.2)

Article XII.— A MOUNTED SKELETON OF THE COLUMBIAN MAMMOTH (*ELEPHAS COLUMBI*).

By Henry Fairfield Osborn.

The skeleton which is the subject of this brief notice was found near Jonesboro, Ind., in 1903. It was purchased for the Museum August, 1904,

Fig. 1. The Columbian Mammoth (*Elephas columbi*).

from Dora S. Gift and others. The skeleton was imbedded in a muck deposit of late Pleistocene age, fifteen feet below the surface.

The whole upper portion of the skeleton was complete and intact, including the remarkably incurved tusks, which were preserved for their entire length although requiring surface restoration and thorough soaking, and reinforcing with an internal steel rod in plaster to prevent them from crumbling away. Vigorous efforts were made to find the missing lower bones of the limb and the feet but without success. The missing parts are, radius and ulna of both sides, the right tibia and fibula, the fore and hind feet. Thanks to the kind coöperation of Dr. Marcellin Boule of the Museum of Palæontology, Paris, casts were secured of the lower portions of the limbs and of the feet of the great skeleton of *Elephas meridionalis* in the Paris Museum. On arrival in the American Museum these were remodeled, recourse being had for comparison to remains of the feet and limbs of *Elephas imperator*. All this work of restoring and remodeling was done by Mr. O. Falkenbach under the direction of Mr. Adam Hermann. Mr. Hermann himself restored the missing surfaces of the upper parts of the skeleton, which was, however, in exceptionally complete condition.

The animal is represented with uplifted head and as if just starting to walk. For the pose of the skeleton the coöperation of the Director of the Zoölogical Park was secured, and the tracks of the Indian elephant slowly walking over a sandy surface fifty feet long were carefully plotted by the park engineer Mr. Beerbower. Through this means it is believed that the fore and hind feet are correctly placed. Mr. Hermann also made a special study of the position of the bones of all parts in the living elephant. Valuable suggestions were also made by Dr. W. D. Matthew and Mr. F. A. Lucas. The result of all this work is a mount which is believed to be true to life.

The size of the animal is indicated by the following comparisons with the great *Elephas meridionalis* of the Paris Museum:

	E. columbi Amer. Museum	*E. meridionalis* Paris Museum (Measurements given by Gaudry).
Length, incurved tip of tusks to vertical line of tail	17 ft. 9½ in. (5.43 M.)	22 ft. 3½ in. (6.8 M.) [1]
Length, base of tusks to vertical line of tail	13 ft. 3⅓ in. (4.05 M.)	14 ft. 7¼ in. (5.45 M.)
Height at withers (to top of scapula)	10 ft. 6 in. (3.20 M.)	12 ft. 6½ in. (3.83 M.) [2]
Length of femur	4 ft. 1¼ in. (1.25 M.)	4 ft. 5½ in. (1.36 M.)
Length of right tusk (outside curve)	11 ft. 4½ in. (3.47 M.)	

[1] The tusks point forward, thus making this dimension much greater than in the American specimen.

[2] Measurement to top of dorsal spine (?). The spines may be too high with reference to the scapula.

The most striking features of this animal are the following:

1. The complete incurvature and crossing of the tusks.
2. The unusually small size of the skull.
3. The abbreviation of the back and body in contrast with the vertical elongation of the limbs.

Fuller details will be given in a forthcoming review by the present writer on the extinct elephants of North America.

59.9, 725 E : 14.71

Article XIII.— POINTS OF THE SKELETON OF THE ARAB HORSE.

By Henry Fairfield Osborn.

The blood of the so-called Arab horse, which Ridgway believes to be of very remote North African or Libyan origin, is very widely diffused, not

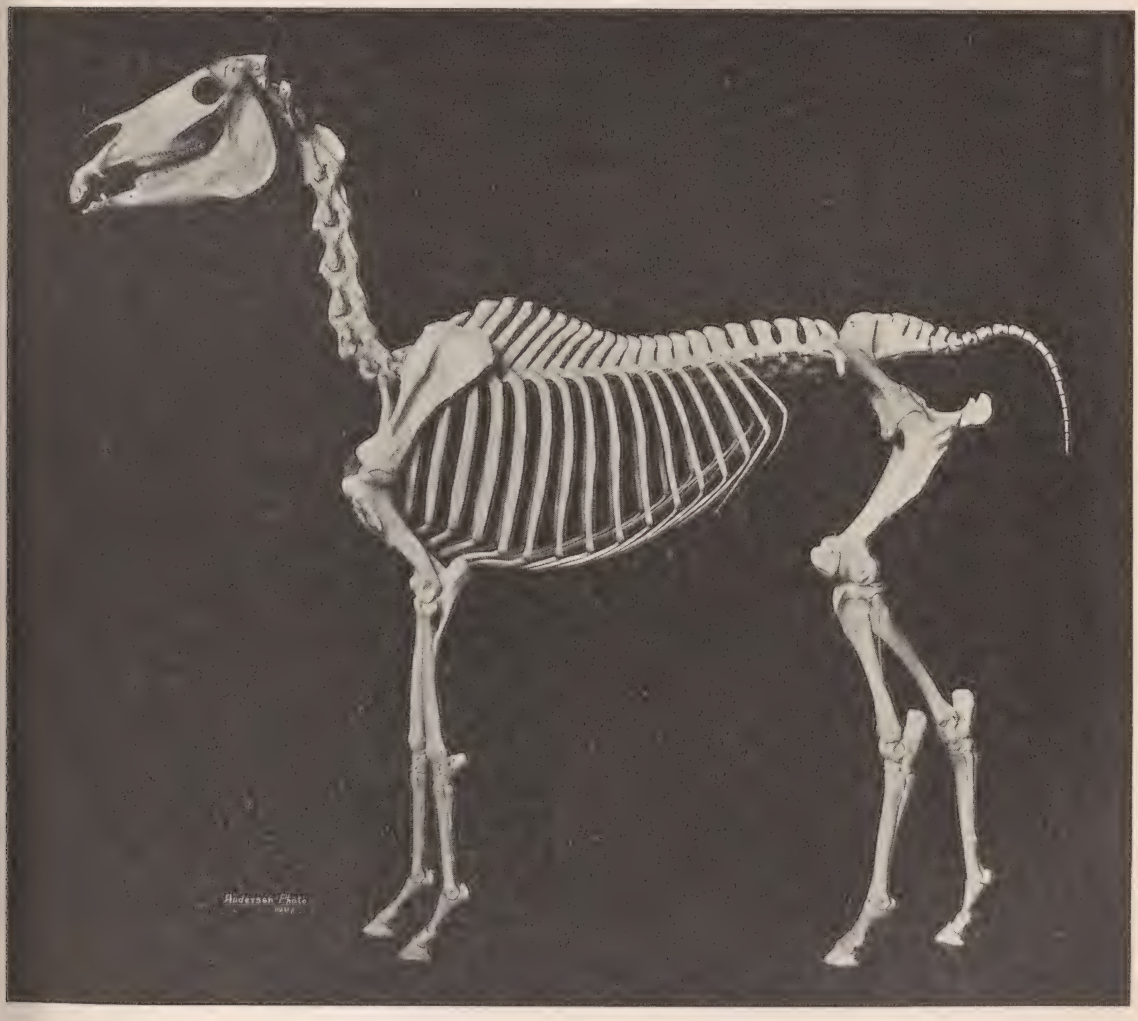


Fig. 1. Skeleton of the Arab Horse 'Nimr'.

only among the thoroughbreds but among the finely bred horses of different types in all parts of the world. Many so-called Arabs are what the Arabians

themselves would call 'sons of horses,' that is, half Arab and half ordinary or northern blood.

The American Museum of Natural History has acquired the skeleton of 'Nimr,' a gift from Mr. Randolph Huntington of Oyster Bay, L. I. (February, 1904). This animal was sired by the desert bred 'Kismet,' a famous race horse, and it has a very direct pedigree and history. It is probably as pure an example as can be found of the modern Arab, somewhat enlarged and modified by favorable western environment and abundant food. It has been mounted with consummate skill by Mr. S. H. Chubb for the Museum collection showing the evolution of the horse. The following

Fig. 2. 'Nimr'.

notes on the skeleton of this animal are published with the hope of securing additional observations.

In the Arab both head and tail are carried 'high' when animated, and in this skeleton all the Arab characters are brought out as follows:

1. Skull short, but broad between the eye sockets.

2. Eye sockets high and prominent, giving the eyes a wide range of vision.

3. Facial profile, or forehead, concave.

4. Jaw slender in front, deep and wide set above the throat.

5. Round ribbed chest, well 'ribbed up' and short back with only 5 ribless, or lumbar, vertebræ.

6. A horizontally placed pelvis (a speed character) and very high tail region, few tail vertebræ.

7. A complete shaft of the ulna, or small bone of the forearm.

8. Long and slender cannon bones, and long, sloping pasterns.

The most distinctive feature of horses of North African stock was pointed out by Sanson[1] in 1866, namely: that they possess five instead of six lumbar vertebræ. 'Nimr' shows this character; it is present in the skeleton of 'Lexington' in the U. S. National Museum; also in the mounted skeleton of a thoroughbred in the British Museum. Correlated with the very characteristic elevation of the tail in Arab horses we observe the upturned sacral and anterior caudal vertebræ, and the remarkably horizontal position of the pelvis in comparison with the relatively downturned caudals and more oblique pelvis of the northern or draft type of horse. A third feature is the very short dock; there are only 16 vertebræ in the tail of 'Nimr,' as compared with 18 vertebræ in the tail of the large draft horse and other horses of northern type. Abbreviation of the tail bones seems to have been a feature in the evolution of these animals. A fourth character of great interest is the complete shaft of the ulna, which for a short interval is actually free from the radius and extends continuously into the lower portion of the bone, which expands and supports the inner upper surface of the cuneiform; I have observed this character also in 'Lexington.'[2] Fifth, the Arab skeleton is noted for the density of its bone. Whatever may be true of the desert-bred Arab this does not especially apply to the stable-bred 'Nimr,' as shown by the following measurements by Mr. Chubb.

	Bones of one front limb			Bones of one hind limb.		
[Specimen	Weight of bones	Cubic inches in bones	Cubic inches per lb. of bone	Weight of bones	Cubic inches in bones	Cubic inches per lb. of bone
Arab (Nimr)	5 lbs.	141	$28\frac{1}{5}$	7 lbs.	200	$28\frac{4}{7}$
Shetland	$\frac{3}{4}$ "	$21\frac{1}{2}$	$28\frac{2}{3}$	1 "	29	29
No. 14131	$6\frac{3}{4}$ "	179	$26\frac{1}{2}\frac{4}{7}$	$8\frac{1}{4}$ "	248	$30\frac{2}{3}\frac{2}{3}$

Sixth, the skull of 'Nimr' is marked not only by the prominence of the brain case, correlated with the large brain, but by the prominence and

[1] Comptes rendus Acad. Sci. Paris, 1866, p. 485, and Mémoire sur la détermination d'une type specifique de race chevalin à cinq vertèbres lombaires. Jour. de l'Anat. et de le Physiol. de M. Robin, t. V, 1868; also Comptes rendus, 1869.

[2] Also in the skeleton of a Grevy Zebra in the American Museum Collection.

superior position of the orbits with breadth of forehead, and by the consequent depression of the profile of the face below the orbits, giving the characteristics Grecian or 'dish' profile in the Arab head. Seventh, the sagittal crest as well as the origin of the temporalis muscle is unusually well defined. Similarly the crest below the orbit for the masseteric origin as well as the fossæ for the insertion of the masseteric muscles in the angular region of the jaw are sharply defined, the expansion of this angular region below the level of the ramus being a very characteristic feature of the Arab. Another mandibular feature is the slenderness and tapering of the jaw anteriorly. In short, the cranium of the Arab skull is of a very distinctive, high bred type and will be readily recognized from that of the cart horse type although several of its characters might be seen blended in the skulls of common

Fig. 3. 'Kahled', son of 'Nimr'.

horses having more or less Arab ancestry. Lydekker has called attention to a slight depression just below and in front of the eyes in the malar region as characteristic of the skulls of several thoroughbreds; he speaks of it as representing the vestigial pit of a face 'gland.' This is undoubtedly a significant character, but we do not find much trace of it in the skull of 'Nimr.'

The neck is much longer relatively than that of the Shetland.

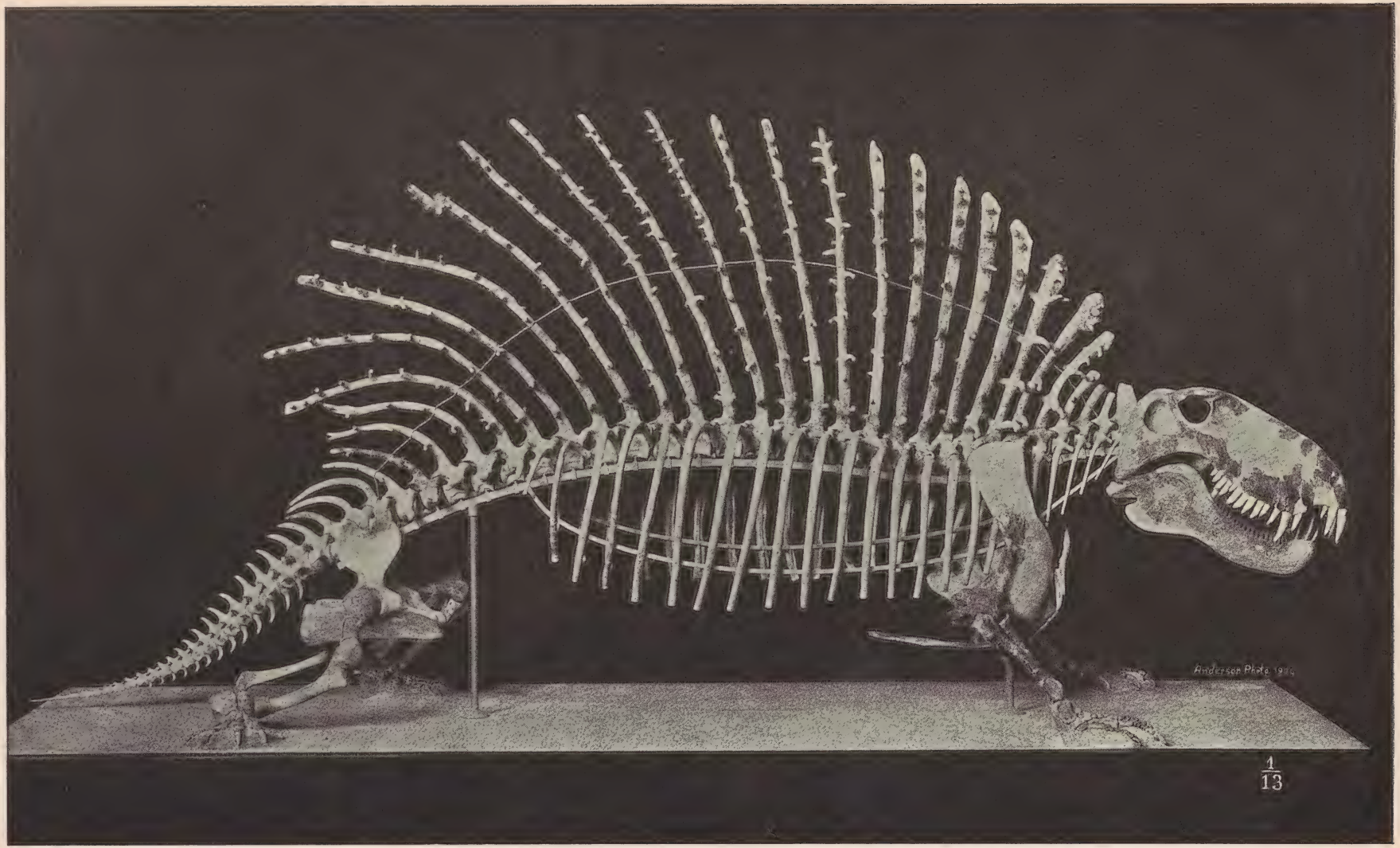
Altogether in my opinion these osteological characters justify the separation of the Arab as a distinct species (*Equus africanus* Sanson), of distinct origin and from wild ancestors very different from those of the northern horse.

Measurements of 'Nimr'.

By S. H. Chubb.

Total length of vertebræ	248 cm.	8 ft.	$1\frac{5}{8}$ in.
" " " skull	53	1	$8\frac{3}{4}$
Height at withers	147	4	10
" " pelvis	145	4	9
Length of scapula to cartilage	36	1	$2\frac{1}{8}$
" " innominate	38	1	$2\frac{7}{8}$
" " humerus	32	1	$\frac{5}{8}$
" " femur	40	1	$3\frac{3}{4}$
" " radius	37	1	$2\frac{1}{2}$
" " tibia	38	1	$2\frac{7}{8}$
" " cannon bone (fore)	261 mm.		$10\frac{5}{8}$
" " " " (hind)	305	1	
" " prox. phalanx (fore)	86		$3\frac{3}{8}$
" " " " (hind)	84		$3\frac{5}{16}$
Transverse diameter of cannon bone (fore)	34		$1\frac{3}{8}$
" " " " " (hind)	32		$1\frac{1}{4}$
" " " prox. phal. (fore)	35		$1\frac{3}{8}$
" " " " " (hind)	35		$1\frac{3}{8}$
" " " thorax	57 cm.	1	$10\frac{1}{8}$
Vertical " " "	56	1	10

Model of *Naosaurus claviger*, by Charles R. Knight, based upon the mounted skeleton shown in Plate X.



Composite skeleton of a large Pelycosaurian Lizard, from the Permian of Texas. (Composed of assembled parts chiefly belonging to the genera *Naosaurus* and *Dimetrodon*.)

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Article XIV.— A MOUNTED SKELETON OF *NAOSAURUS*, A PELYCOSAUR FROM THE PERMIAN OF TEXAS.

By Henry Fairfield Osborn.

Plates IX and X.

The more or less complete skeletons of the Permian Pelycosauria *Naosaurus* and *Dimetrodon* constitute some of the finest and most interesting portions of the Cope Permian collection presented to the American Museum by Mr. Morris K. Jesup. The present article is devoted to a preliminary description of a composite skeleton of a Permian Pelycosaurian mounted with great skill by Mr. Adam Hermann under the writer's direction with the coöperation of Dr. W. D. Matthew.

The assemblage in this imposing mount, which has a total length of 8 ft. 6½ inches or 2.62 m., represents a large number of individuals arbitrarily associated with the chief specimen (Amer. Mus. No. 4015), collected by Mr. Sternberg in 1896 on Hog Creek, Baylor County, Texas. This chief specimen includes all the vertebræ and ribs except those parts which are obviously restored in plaster; clavicles, and epiclavicles; a portion of the scapula not used was doubtfully associated. The association of the other parts collected by Messrs. Boll (1880) and Cummings (1882) is highly conjectural. Dr. E. C. Case, the chief authority on this group writes his belief that the skull of *Dimetrodon* cannot be used as a basis for the restoration of the skull of *Naosaurus*.

The reader will, therefore, thoroughly understand that the assemblage is largely composite. It serves, nevertheless, to give us for the first time an adequate conception of the unique and imposing characters of these great extinct forms.

Detailed List of Parts Assembled.— It is important at once to record the catalogue numbers and the localities of the specimens used in this assemblage:

No. 4015. Sternberg, 1896, Hog Creek, Baylor Co., Texas.
All vertebræ and ribs (except as restored in plaster); *clavicles* and *cleithrum*. Part of scapula not used; doubtfully associated.

No. 4081. Ball, 1880. North Fork of Little Wichita River, Texas.
Skull and jaws except as restored in plaster. (The right jaw, a large part of right side of skull, and smaller part of left side, are bone. All teeth are restored.)

No. 4057. Cummins, 1882. Elm Creek, Texas.
Fore and hind limbs, in part, as follows: right radius and ulna, ulnare,

radiale, carpale II, metacarpals I–IV, phal. II; left femur, right and left tibiæ, right astragalus. Scapulæ, parts of humeri, pelvis, and many vertebral centra not used. A part of a single spine preserved, and the length of the tail indicates this as *Dimetrodon* rather than *Naosaurus*. The length and character of limbs and feet is not sufficiently different to prevent its being used in the *Naosaurus* skeleton.

No. 4145. Sternberg, 1895. Coffee Creek, Baylor Co., Texas.
Scapulæ, humeri, left radius and ulna. Femur not used. This specimen agrees pretty closely with No. 4057 in parts comparable, but is somewhat more robust.

No. 4163. Sternberg, 1902. Coffee Creek. Composite number, bone bed.
Nearly all phalanges, parts of several metapodials and distal tarsals.
The Pelycosaur material in this lot was sorted out and is mostly of appropriate size.

No. 4103. Indian Creek, Texas.
Interclavicle. Scapula, not used. Somewhat too large for No. 4057, but may not be too large for No. 4015, which is more robust than No. 4057.

No. 4132. Right femur.
Unnumbered specimens. Calcaneum, two carpals, a few phalanges.

The above numbers are from the American Museum catalogue as determined by Messrs. Matthew, Case, and Gregory. Dr. W. D. Matthew furnishes the following additional notes:

Limbs and feet.— The limb and foot material in the Museum collection does not include anything that can be *certainly* regarded as belonging to *Naosaurus*; all the best limb and foot material is in association with *Dimetrodon*, but since *Naosaurus* is about as abundant as *Dimetrodon* it is fair to infer that about half of the unassociated limb and foot material belongs with *Naosaurus*. It is probable that *Naosaurus* was a somewhat more robust animal, but otherwise much like *Dimetrodon*. The limbs and feet used in this assemblage may fairly represent *Naosaurus* but more probably belong to a large species of *Dimetrodon*.

Vertebræ.— The central specimen (Amer. Mus. No. 4015) includes the greater number of vertebræ. The characters here shown are confirmed by two other remarkably complete vertebral series with spines. The chief characters of the atlas and axis are well ascertained from Amer. Mus. Nos. 4034, 4040, referred by Dr. Case to *Dimetrodon gigas* and *D. incisivus* respectively (Fig. 1). The length of the tail is inferred to be exceptionally short in *Naosaurus*, chiefly because of the absence of any large or long caudals in association with any of these giant Pelycosauria. In *Dimetrodon* it was apparently somewhat longer than in *Naosaurus*.

Skull.— As above noted, the association of the skull is highly conjectural; its size and robustness as compared with that of *Dimetrodon* constitute the principal ground for this association.

We are struck by the enormous and powerful head, which was supported

by ligaments attached to the stout neural spines of the anterior cervicals and dorsals, the elongate back, from which radiate like the rays of a fan the greatly elongated neural spines, the transverse bars of which suggested the name *Naosaurus* or 'ship lizard' to Professor Cope. Anteriorly the spines almost overhang the back of the head, posteriorly they are sharply retroverted into a horizontal plane. The fore limbs are supported by a very powerful shoulder girdle. The hind limbs are relatively large and more powerful. The horizontal position of the humerus and femur and the sharp angulation of the ankle joint are conditioned by the peculiar position of the articular facets. The pose is taken from a careful study of some of the existing lizards.

Details of Structure.

1. The skull is modeled from comparative study of several Pelycosaur skulls in the American Museum with the assistance of one loaned by Professor S. W. Williston from the University of Chicago. It is probably substantially correct. The position of the lower canines is determined by deep,

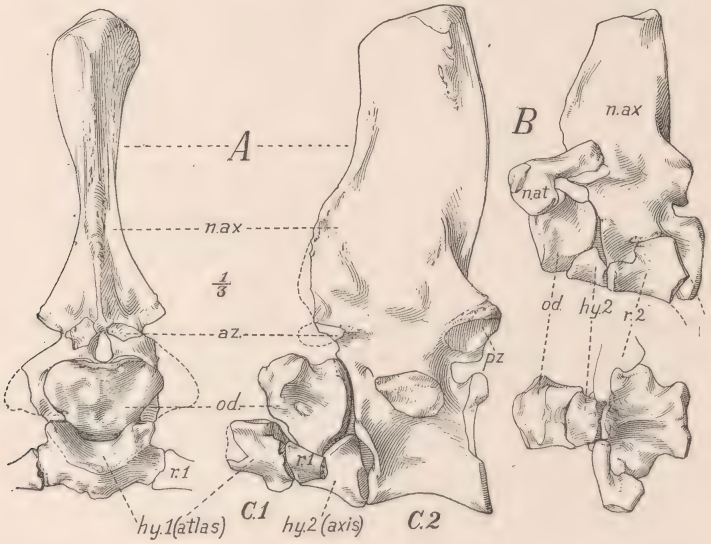

Fig. 1. Axis and atlas complex of the Pelycosauria. *A*, No. 4034 Cope Collection, American Museum. Anterior and lateral aspects. *B*, No. 4040, Cope Collection, American Museum. Lateral and inferior aspects. The dorsal border of *n. at.* was probably broadly convex.

lateral grooves on the outer sides of the premaxillaries. The face is strongly convex, the orbits are large, the temporal fenestræ are contracted by the powerful bones of the temporal region.

2. *Cervicals.*— The structure of the atlas and axis is very primitive, as determined from American Museum Nos. 4034 *Dimetrodon gigas* (fide Case) 4040 *D. incisivus* (fide Case), and represented in Fig. 2, A, B.

In the smaller specimen (No. 4040, Fig. 2B) the odontoid or atlanteal pleurocentrum reaches the ventral line of the vertebræ, and the facet for the hypocentrum is almost on the same transverse plane with the facet for the skull. The spine of the atlas is relatively low. In the larger specimen (No. 4034, Fig. 2 A) the odontoid is excluded from the ventral line by hypocentra 1 and 2, and the facet for hypocentrum 1 is very oblique.

In No. 4040 the odontoid supports the distinct halves of the neural arch of the atlas (*N. at.* Fig. 2 B), as in *Champsosaurus* and other primitive Diapsida. Each half of this neural arch[1] has a large facet for the odontoid. It also articulated postero-dorsally with the prezygapophysis of the axis, and probably also distally with the atlanteal hypocentrum (*hy 1*) which in No. 4034 (*D. gigas*) shows a distinct articular depression on its dorso-lateral border. In No. 4034 (Fig. 2 A) the first rib certainly articulated with the postero-lateral border of hypocentrum 1, and possibly may also have articulated dorsally with the postero-inferior portion of the atlanteal neural arch, as observed by Dr. Case in his specimen No. 131. The second rib articulates by the tubercle with hypocentrum 2 (of the axis) and by its capitulum with the diapophysis of the axis.

The neck was apparently abbreviate, each vertebra behind the atlas being provided with large, free two-headed ribs.

3. The vertebræ excepting the sacrals and ? anterior caudals were provided with free hypocentra. The centra are perforated by the notochordal tube. The vertebral centra (pleurocentra) are relatively small and reduced, especially in the anterior dorsal region where as supporting structures they are more or less functionally replaced by the enormously enlarged neural spines.

4. The neural spines of the anterior dorsals are directed upward and partly expand at the extremities to support the stout ligaments attached to the occipital surface of the skull. As we pass backward the spines become more slender and assume a vertical, an oblique, and finally a curved retroverted position horizontally overhanging the sacrum and anterior portion of the tail. The vertebral formula is approximately:

Rib-bearing cervicals	?5
Rib-bearing dorsals	19.
Sacrals	3.
Caudals	25.

5. The post-atlanteal ribs articulate by the capitulum with the hypocentrum or are intercentral in position; the tuberculum of each is pleurocentral being attached to the sides of the succeeding vertebra.

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[1] Owing to the crushed condition of the specimen, the shape of the neural arch is incorrectly represented in the drawing. Its dorsal border should be convex.

6. The short, stout shoulder girdle includes a very large plate-like scapula. The suture between the coracoid and procoracoid cannot be made out.

The clavicular arch includes: (1) epiclavicles, (2) clavicles, (3) the elongated interclavicle or episternum. The close articulation of clavicles and interclavicle is clearly observed.

7. *The manus.*[1]—The reconstruction of the manus and pes (hypothetically arranged in Fig. 3), is due to Dr. Matthew. The carpus apparently comprises the following parts: radiale, intermedium, ulnare, 2 centralia, 5 distinct carpalia. The phalangeal formula is that of the typical Diapsida, namely, 2, 3, 4, 5, 4. A primitive feature characteristic of other Diapsida, such as *Sphenodon* and *Stereosternum* is an intracarpal foramen (*for.*) indicated by a curve in the mesial aspect of the ulnare. An analogous intratarsal foramen in the pes is indicated by a curve in the mesial aspect of the fibulare.

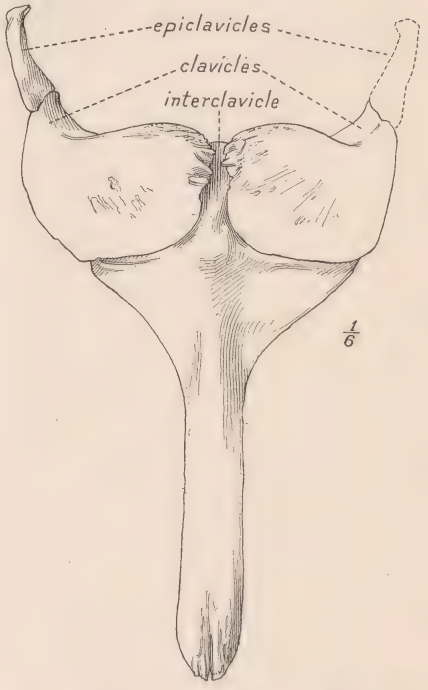

Fig. 2. Clavicular arch. The breast plates attributed to *Naosaurus*. Cope Collection, No. 4103, American Museum.

8. *The pes.*— The first character of this hypothetical restoration is the sharp or right angle in the ankle joint. Thus the fibula articulates with the internal face of the fibulare, the tibia with the internal face of the supposed tibiale + intermedium. The bone corresponding to the navicular is provisionally interpreted as centrale 1 (as indicated by Broom's figure of the pes of *Procolophon*). There is a space for another small centrale tarsi (possibly for two centralia) although in the restoration centrale 3 is indicated as coalesced with tarsale 4. The phalangeal and digital formula are hypothetically represented as in the manus.

In both manus and pes the terminal phalanges are of the locomotor rather than of the prehensile type, that is, they were provided with flattened rather than with sharply recurved claws.

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[1] Owing to the fact that the manns is reconstructed from several specimens the intermedium is probably too small in the drawing and does not extend sufficiently upward between the radius and ulna. Centrale 2 is also probably incorrect in form (Matthew).

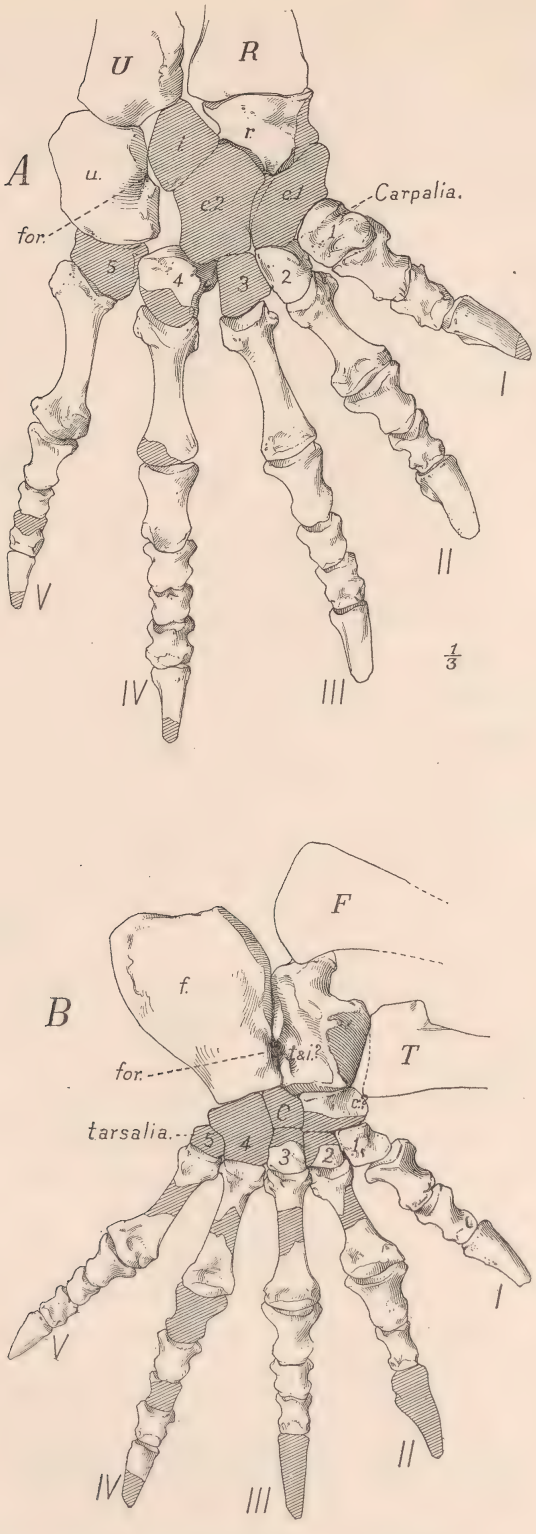
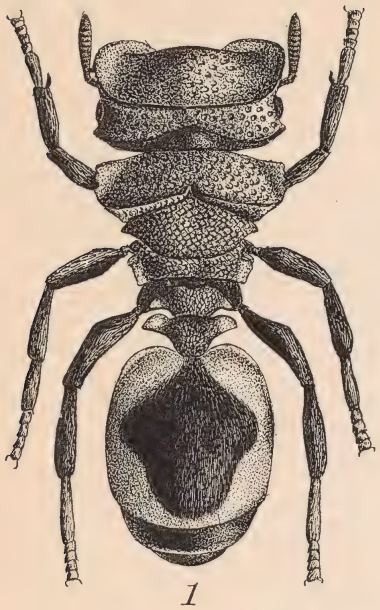


Fig. 3. *A*, manus, *B*, pes, of a large Pelycosaur. Composition, from a number of different individuals.



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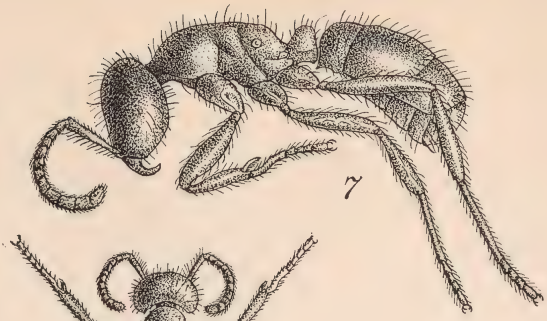

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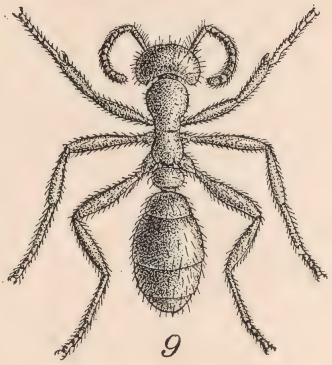

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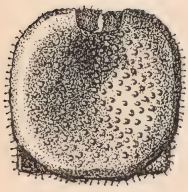

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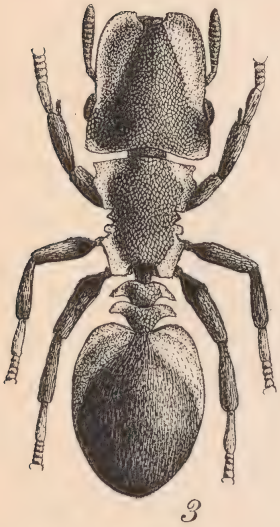

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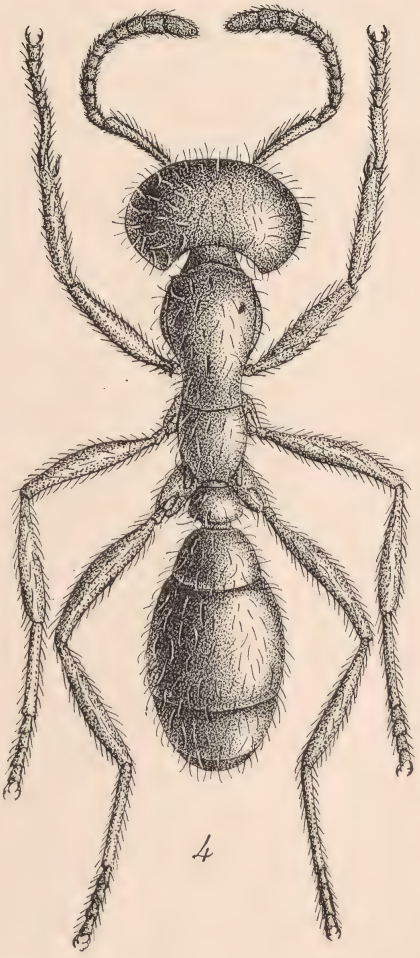

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R. B. Howe del.

ANTS FROM BRITISH HONDURAS.

Pendant Carton Nest of *Azteca schimperi* Emery.

59.57, 96 (728)

Article XV.— A COLLECTION OF ANTS FROM BRITISH HONDURAS.

By William Morton Wheeler.

Plates XI and XII.

The collection of ants enumerated in the following pages was made during the autumn and winter of 1905–'06 by Mr. J. D. Johnson at Manatee, British Honduras. Although the specimens all belong to known species, they are interesting on account of the locality in which they were taken, as British Honduras is very rarely mentioned among the localities in Forel's admirable monograph of the Central American and Mexican ants in the 'Biologia Centrali-Americana.'

Ponerinæ.

1. **Pachycondyla harpax** *Fabr.*—Three workers indistinguishable from the typical form from Texas and Mexico.

2. **Pachycondyla** (**Pseudoponera**) **stigma** *Fabr.*— Numerous workers and a few males from several colonies.

3. **Anochetus** (**Stenomyrmex**) **emarginatus testaceus** *Forel.*— Numerous workers closely resembling in color the typical form of this subspecies from the West Indies and in having the anterior surface of the petiole smooth above and only moderately rugose near the base.

Dorylinæ.

4. **Eciton hamatum** *Fabr.*— Many soldiers and workers.

5. **Eciton vagans** *Oliv.*— Numerous workers.

6. **Eciton rogeri** *Dalla Torre.*— Numerous workers.

7. **Eciton prædator** *F. Smith.*— Numerous workers.

8. **Cheliomyrmex nortoni** *Mayr.* (Pl. XI, Figs. 4–9.)— Many workers measuring from 2.5 to 6 mm. in length, from two colonies. There can be no doubt that this ant forages in files like the species of *Eciton*. It is probably hypogæic like *E. cæcum* Latr. As Emery has shown, *C. nortoni* has dimorphic workers. The largest individuals (soldiers) have curved, falcate mandibles with a narrow, hooked apical and two large basal teeth (Pl. XI, Fig. 5) whereas the intermediates and small workers have short and proportionally broad mandibles, with only two large teeth separated by a series

of denticles. (Pl. XI, Fig. 8.) As in the genus *Dorylus* the clypeus is also more convex and projecting in the smaller than in the larger workers.

MYRMICINÆ.

9. **Pseudomyrma belti** *Emery* var. **fulvescens** *Emery.*— Many workers of the typical form of this variety.

10. **Pseudomyrma dolichopsis** *Forel.* — Several workers which agree perfectly with Forel's description except in size. They are only 3–3.3 mm. in length and may belong to an incipient colony.

11. **Pseudomyrma sericea** *Mayr.*— A single worker.

12. **Pseudomyrma caroli** *Forel.* — Numerous workers agreeing very closely with Forel's description of specimens from Costa Rica and with a type specimen of the var. *clapii* Forel from the Amazon.

13. **Pseudomyrma delicatula** *Forel.*— Four workers.

14. **Monomorium carbonarium ebeninum** *Forel.*— Many workers of the typical form of this subspecies.

15. **Monomorium floricola** *Jerdon.*— Numerous workers.

16. **Solenopsis geminata rufa** *Fabr.* — Many workers of the typical East Indian form of this common tropicopolitan ant. They are of a reddish yellow color, with a well developed spine on the mesosternum. The largest specimens measure only 3.5–4 mm.

17. **Pheidole anastasii** *Emery* var. **johnsoni** var. nov. — Numerous soldiers, workers and males taken from a single colony (Feb. 2). The soldiers and workers resemble the corresponding phases of *anastasii* except in having the whole head, thorax and pedicel opaque as in *punctatissima* Mayr. The color is that of *anastasii.*

18. **Pheidole megacephala** *Fabr.*— Several soldiers and workers of the typical form.

19. **Cremastogaster brevispinosa** *Mayr.* — Many workers from several colonies marked "small black house-ant." Among these are a number of pseudogynic individuals not exceeding the largest workers in size (2.3 mm.), with an enlarged mesonotum and sometimes with a small scutellum and minute nodular or strap-shaped vestiges of fore wings. These abnormal individuals are of exactly the same character as the pseudogynic specimens of *Myrmica* which I have described and figured in a former paper.[1]

20. **Cryptocerus cristatus** *Emery.*— A worker and two females. The wings of the latter are smoky brown, with heavy dark brown veins and stigma.

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[1]The Polymorphism of Ants, with an Account of Some Singular Abnormalities due to Parasitism. Bull. Am. Mus. Nat. Hist., Vol. XXIII, 1907, p. 43, pl. iv, figs. 45–49.

21. **Cryptocerus angulosus** *F. Smith.*

(Plate XI, Figs. 1–3.)

Cryptocerus angulosus F. Smith, Trans. Ent. Soc. London, 1867, p. 525, pl. xxvi, fig. 7. ☿.

Cryptocerus jucundus F. Smith, Trans. Ent. Soc. London, 1876, p. 606, pl. xi, Fig. 2, ☿.

Cryptocerus angulosus Emery, Bull. Soc. Ent. Ital., XXII, 1890, p. 39, tav. ix, fig. 9, ☿.

Soldier. (Pl. XI, Figs. 1 and 2.) Length: 4.6–5 mm.

Head surmounted by a disk, which is as long as broad, with straight, parallel sides and rounded anterior and posterior corners. The floor of the disk is convex in the middle and anteriorly, and very concave on the sides, with a thin, reflected and irregularly crenate border. Its anterior border is semicircularly excised in the middle, and encloses the mandibles, each of which has a long, acute apical, and a few indistinct basal teeth. Posterior corners of head projecting below and beyond the disk, rather acute, turned upwards and irregularly crenate. Thorax as broad as long, about twice as broad in front as behind. Promesonotal and mesoëpinotal sutures very distinct, the former subsemicircular, the latter but slightly curved. Pronotum with sharp, flattened anterior angles and a strong transverse, irregularly crenate, posterior crest, narrowly interrupted in the middle. Mesonotum somewhat more than half as broad as the pronotum, produced on each side into a short, sharp angle. Epinotum nearly as broad as the mesonotum, with thin, flat lateral borders, except in front where it is suddenly narrowed and produced into a small rounded lobe on each side. The lateral borders converge posteriorly and have blunt posterior angles. Petiole and postpetiole alike in shape and both with well-developed, recurved lateral spines, these on the petiole being, however, distinctly narrower, more acute and less flattened than those on the postpetiole. Grasor less than twice as long as broad, flattened, bluntly pointed behind, cordate in front, with thin, slightly upturned anterior borders. Legs robust.

Subopaque; upper surface of head shining. Head and thorax foveolate, the former more coarsely and much more sparsely, especially on the concave portions of the disk. Petiole, postpetiole, gaster and legs finely and densely foveolate-punctate.

Hairs glistening white, very short, scale-like and appressed, one to each of the foveolæ on the head and thorax; much smaller and denser on the remainder of the body. Edge of cephalic disc with a fringe of short, erect, clavate hairs.

Black; upper surface of head, pronotum, tibiæ, terminal tarsal joints, scapes and basal funicular joints of antennæ, brownish yellow. Lateral borders of epinotum, spines of postpetiole and all but a large lozenge-shaped area on the disc of the first gastric segment, sordid white, as are also the posterior borders of the remaining gastric segments.

Worker. (Pl. XI, Fig. 3.) Length: 3.5–4 mm.

Head not surmounted by a disk, longer than broad, narrower in front than behind, with sides straight and gradually converging in front, and with rounded, thin anterior lobes and distinct posterior angles. Anterior border with a semicircular excision for the mandibles. Thorax nearly $1\frac{1}{2}$ times as long as broad, flattened above, without a pronotal crest; promesonotal suture obsolete, mesoëpinotal suture very indistinct. Pro- and epinotum each somewhat broader than

long, with thin, dilated lateral borders, and each with a notch just behind its anterior angle. Mesonotum produced on each side into a short spine. Petiole and postpetiole similar to those of the soldier. Gaster cordate-elliptical, proportionally shorter than in the soldier.

Opaque; whole surface finely and densely granulate-foveolate, the head, thorax, petiole and postpetiole somewhat more coarsely than the gaster.

Hairs similar to those of the soldier but shorter; finer and denser on the gaster and legs than on the remainder of the body.

Black; anterolateral lobes and posterior corners of head, lateral borders of thorax, spines of petiole and postpetiole, anterolateral corners of first gastric segment, antennæ, knees and tibiæ, sordid or brownish white.

Male. Length: 4.5–5 mm.

Head, excluding eyes, broader than long, convex behind, with very short, concave cheeks. Mandibles with an acute apical and several small basal teeth. Antennæ short, not much incrassated towards their tips; scape much shorter than the second funicular joint, first funicular twice as broad as long, joints 2–11 subequal, less than twice as long as broad, rather robust, terminal joint somewhat shorter than the two preceding joints together. Thorax robust, somewhat broader through the wing insertions than the head through the eyes; Mayrian furrows of pronotum broadly impressed, shallow. Epinotum short, basal surface shorter than the abrupt declivity with which it forms nearly a right angle. Petiole and postpetiole subequal, rectangular from above, a little longer than broad.

Opaque; petiole, postpetiole and gaster shining. Head and thorax densely punctate or granular, the former with small, the latter with larger, shallow foveolæ. Mayrian and parapteral furrows coarsely longitudinally rugose. Petiole, postpetiole and gaster coarsely shagreened.

Hairs whitish, tapering, rather abundant, suberect; conspicuous on the body but much sparser on the legs.

Black; mandibles, antennæ and legs white; bases of mandibles, the scapes and bases of fore femora more or less infuscated. Posterior edges of gastric segments and genitalia yellowish. Wings whitish hyaline, with colorless veins and light brown stigma.

Described from numerous soldiers, workers and males, all taken from the same colony (Jan. 31).

22. **Atta cephalotes** *Linn.* — Numerous small and medium sized workers of this, "the wee-wee, or mound-builder," which is one of the few ants also cited by Forel from British Honduras.

23. **Atta (Trachymyrmex) saussurei** *Forel.* — Closely related, as Forel has shown, to *A.* (*T.*) *septentrionalis* of the United States. The numerous workers received from Mr. Johnson agree well with a typical specimen of *saussurei* given me by Mr. Pergande. They differ from *septentrionalis* in having a narrower head, much more convex and protruding eyes, longer antennal scapes, which surpass the posterior corners of the head by nearly $\frac{1}{3}$ their length, and more acute thoracic spines, of which four instead of three pairs may be seen on the profile of the pro- and mesonotum. The postpetiole is as long as broad instead of broader than long; the tubercles on

the gaster are larger and less numerous than in *septentrionalis* and the median black band is less distinct.

The hitherto undescribed female of *saussurei* differs from that of *septentrionalis* in the longer antennal scapes and postpetiole and the grosser tubercles, especially on the gaster. The first segment of the latter has a median and two lateral streaks of dark brown, and the ventral surface is also infuscated. The mesonotum has a large, triangular anteromedian and two lateral dark brown blotches and there is a similar blotch on the clypeus, one on the vertex and another on the scutellum. The wings are smoky brown, somewhat paler than those of *septentrionalis*.

In the hitherto undescribed male of *saussurei* the head is narrower behind and with blunter spines than in *septentrionalis*; the antennæ and legs are more slender, the postpetiole longer and with a pronounced transverse depression, and the tubercles on the petiole, postpetiole and gaster are much more prominent.

All the specimens received from Mr. Johnson were taken from the same nest (Feb. 9).

24. **Myrmicocrypta dilacerata** *Forel.*— Two males.

25. **Cyphomyrmex rimosus** *Spinola.*— Numerous workers of the typical form of this variable species.

Dolichoderinæ.

26. **Dolichoderus bispinosus** *Olivier.*— Numerous workers from two colonies, together with some Membracids which they were attending. This common and widely distributed neotropical species is cited by Forel from the Rio Hondo, British Honduras. Like several other species of the genus it constructs paper nests.

27. **Dolichoderus championi** *Forel.*— Numerous workers and a single deälated female. Forel has described all three phases of this insect from Mexico, Costa Rica and Panama, and also a subspecies and variety from Trinidad and Colombia.

28. **Tapinoma melanocephalum** *Fabr.*— Many workers from a single colony. This species appears to be widely distributed through the tropics of both hemispheres. It is common in the West Indies (Jamaica, Porto Rico, Bahamas) and has also been introduced into well-heated buildings in New York. During the past winter I have seen it visiting the sugar bowls on the tables of the Columbia University commons.

29. **Dorymyrmex pyramicus** *Roger.*— Numerous workers of the typical form of this species from two colonies.

30. **Azteca instabilis** *F. Smith.*— Many workers of all sizes and four-

teen winged females from four colonies (Nov. 1 and 14). The females are 9.10 mm. long. The head, excluding the mandibles, is very little longer than broad, convex and rounded on the sides behind the eyes, contracted and concave in the region of the cheeks and with a broad, shallow occipital excision. The tips of the antennal scapes reach to a little more than $\frac{2}{3}$ the distance between the eyes and the posterior corners of the head. The body is dark brown, with the mandibles, clypeus, antennæ, head, pronotum, thoracic sutures, tarsi, venter, anterior and posterior borders of the gastric segments dull orange yellow. The front and a large portion of the upper posterior surface of the head dark brown. The wings have a pronounced yellow tinge, with dark brown stigma and scapular vein; the remaining veins being light brown. Pile and pubescence like those of the worker; antennal scapes and legs with prominent erect hairs.

31. **Azteca foreli** *Emery.*— Numerous workers of all sizes, agreeing perfectly with Emery's original description of this species.

32. **Azteca schimperi** *Emery.*— Numerous workers of all sizes taken from a paper nest which Mr. Johnson has forwarded to the American Museum. This nest, which is represented in Plate XII, was suspended from the branches of a tree. It is regularly egg-shaped, 15 cm. long and 9.5 cm. through its greatest diameter, and consists of dark brown, hard and friable carton. The outer surface is ornamented with broad flat carton scales of a paler and slightly reddish color. The numerous openings, scattered irregularly over the surface, are mostly elliptical and vary from 3 to 6 mm. in diameter.

Camponotinæ.

33. **Prenolepsis longicornis** *Fabr.*— Numerous workers.

34. **Prenolepsis guatemalensis** *Forel.*— Several workers and males which agree very closely with typical specimens of this species received from Prof. Forel.

35. **Prenolepsis sp.**— Three workers which I hesitate to refer to any of the described species, as they are not accompanied by males.

36. **Camponotus abdominalis ustulatus** *Forel.*— A number of soldiers and workers and two winged females taken Nov. 15, from "an empty hornet's nest."

37. **Camponotus abdominalis stercorarius** *Forel.*— Several soldiers and workers.

38. **Camponotus planatus** *Roger.*— Several soldiers and workers of a pale variety of this common neotropical species.

39. **Camponotus formicæformis** *Forel.*— A number of soldiers and workers.

40. **Camponotus lindigi** *Mayr.*— A few soldiers and several workers.

41. **Camponotus rectangularis** *Emery.*— Numerous soldiers and workers of the light-colored, typical form of this species.

42. **Camponotus claviscapus** *Forel.*— Two soldiers and fourteen workers agreeing perfectly with Forel's description. There are also in my collection two females and two males taken in Nicaragua by Mr. Wm. Fluck. None of these specimens has any trace of a carina on the clypeus so that I am unable to refer them to Forel's var. *carinata* of Guatemala. The female resembles the soldier very closely in the structure of the head and the distally incrassated antennal scapes. The thorax and gaster are long and narrow, the mesonotum being somewhat longer than broad and as broad as the head. The petiole is low and very thick, with blunt horizontal superior border when seen from behind. The gaster is nearly four times as long as broad, brown, with the anterior half of the first segment and a pair of large rectangular blotches on each of the succeeding segments, yellow. The wings are yellowish hyaline, with yellow veins and stigma.

43. **Camponotus sericeiventris** *Guérin.*— Two soldiers and a worker agreeing in all respects with specimens from various parts of Mexico.

EXPLANATION OF PLATES.

Plate XI.

Fig. 1.—*Cryptocerus angulosus* F. Smith. Soldier.
Fig. 2.—Head of same seen from above.
Fig. 3.—*Cryptocerus angulosus* F. Smith. Worker.
Fig. 4.—*Cheliomyrmex nortoni* Mayr. Soldier.
Fig. 5.—Head of same seen from the front.
Fig. 6.—Terminal tarsal joints of same.
Fig. 7.—*Cheliomyrmex nortoni* Mayr. Intermediate worker, in profile.
Fig. 8.—Head of same seen from the front.
Fig. 9.—*Cheliomyrmex nortoni* Mayr. Small worker, drawn to same scale as Figs. 4 and 7.

Plate XII.

Pendent carton nest of *Azteca schimperi* Emery.

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Article XVI.— THE TYPES OF THE NORTH AMERICAN GENERA OF BIRDS.

By J. A. Allen.

I. INTRODUCTORY.

Up to within the last year or two there has been very general agreement as to the method of fixing the types of genera in Zoölogy in cases where the founder omitted to specify the type, and the genus originally contained more than one species. This has been a process commonly known as the method of elimination; it has not only been incorporated in all codes of zoölogical nomenclature down to the latest, the International Code of 1905, but has for more than half a century received the sanction of general usage. It is simply the application of the rule of priority to the dismemberment of polytypic genera. All agree that a generic name proposed for a heterogeneous group of species must be conserved for one of its original components. If, in the course of its dismemberment, all of the species have been removed to other genera, either as types of new genera or as congeneric with such types, the name of the original genus is to be restored to the last component of the group which was thus removed. If a part of the original species have been thus taken out and others left, the author who has occasion to revise the genus can select anyone of the remaining species as its type which in his judgment seems best, and such assignment, by the ruling of all codes, is not subject to subsequent modification. In case none of the original species have been removed the first reviser has the right, under the same rules, to designate any of the original species as the type of the genus.

Ordinarily the determination of types by elimination is not difficult; in the case of very large genera, made up of many heterogeneous elements, considerable labor may be involved, as the nomenclatural history of each species must be traced out before the type can be determined. But the difficulties and uncertainty of result have of late been greatly magnified, and to simplify an imaginary difficulty it has recently been proposed that the first species shall be taken as the type in all this class of cases, regardless of consequences,[1] owing to the simplicity of the method and the facility of its application. Yet so evidently disastrous would be its unrestricted application that the advocates of the 'first species rule' urge the removal

[1] *Cf.*, Stone, Witmer, The Relative Merits of the 'Elimination' and 'First Species' Method in fixing the Types of Genera — with Special Reference to Ornithology. Science, N. S., Vol. XXIV, No. 618, November 2, 1906, pp. 560–565.

of all the Linnæan genera from its scope, on the ground that, in ornithology at least, there is practical unanimity of opinion as to what species are to be regarded as their types. In order to test the comparative merits of the two methods — elimination and the first species rule — in respect to the necessary changes involved in their application, the genera of North American birds are here taken for a trial test. Besides this, it has seemed desirable to have a clear statement of how the types of these genera have been determined, since in most cases we have merely the affirmation that a certain species *is* the type of a given genus, without any intimation as to how many species the genus originally contained or how the type was determined.

There are four conditions, any one of which, when present, determines the type of a genus beyond appeal, under current usage:

1. A genus that is monotypic when founded necessarily takes its only species as the type.

2. When the type is designated by its author at the time of founding the genus.

3. When the name of the genus is the same as that of one of its species, or like that of a synonym of one of its species, or is based upon such a name — in other words, by the rule of tautonomy.[1]

4. When some subsequent author has selected one of its species as its type.

The rule of tautonomy is perfectly rational and satisfactory and helps often to decide otherwise complicated cases. Nearly all of the Brissonian genera come within its scope, as do many others that would otherwise give trouble. In fact, it is included in substance in the original B. A. Code, though not given in the form of a canon. It is, however, evident that many authors have heretofore been guided by it in selecting the types of genera.

The second edition of the A. O. U. Check-List of North American Birds and its subsequent Supplements contain 415 genera and subgenera, the types of which, and the manner of their selection, are set forth in the following pages. As will be seen, a surprisingly large number were monotypic when originally founded, many more are determinable by the principle of tautonomy, and a considerable number have had their types designated by the founder of the genus. A large proportion of those containing two or more species have the first species as the type, although, as will be shown later, many were so determined without any conscious adherence to a 'first species' rule. The types of many genera which originally contained more than one species are types by what may be conceded as practically unanimous

[1] This rule has only recently come into use, but has been found to give such satisfactory results that it has been incorporated into the Code of the International Committee on Zoölogical Nomenclature, published in 1905, and has also recently been adopted by the American Ornithologists' Union.

consent, whether they came to be types by the process of elimination or by the designation of a subsequent author.

Before proceeding to the main subject, a few words seem desirable in respect to one or two collateral questions, namely, that submythical personage, the 'first reviser,' and the importance of the continued acceptance of Brissonian genera.

The First Reviser.

In the past much has been said regarding the decisions of a 'first reviser' in fixing the types of genera. Canon XXI of the A. O. U. Code declares: "When no type is clearly indicated, the author who first subdivides a genus may restrict the original name to such part of it as he may judge advisable, and such assignment shall not be subject to subsequent modification." This is in substance the ruling on this point by the B. A. Code, promulgated in 1842, and reiterated in most subsequent codes down to the International Code of 1905. The reasonableness and utility of this provision has rarely been questioned, and it has consequently been almost universally respected for three quarters of a century. It has, however, happened that in the restriction of comprehensive genera one species after another has been taken out, usually by different authors, without any type being designated for the original genus. In other words, the restriction of the original genus to some one or more of its original components has often been a fortuitous or haphazard process, so that the final determination of the type can be made only through the so-called process of elimination. On the other hand, in not a few cases, the founder or some subsequent author has designated a type species for the original genus when removing its noncongeneric components. In this case, such an author is in a true sense the first reviser. The action in such instances is essentially different from the chance method of removing species at random until all may have been removed without any definite restriction of the original genus. The first reviser, in any true sense, is, therefore, the author who first formally and with definite intent designates a type species for a genus originally proposed without specification of a type, provided that he conforms also to the rule that the type must be one of the originally included species.

Before the promulgation of the B. A. Code, various authors had begun to realize the necessity of definitely designated generic types, and not only specified the type species of their own genera when founding them, but also, in many cases, designated types for genera founded by other authors without specification of a type. As this, however, was before the existence of even the earliest of the modern codes, each author was a law unto him-

self in such matters. Hence the process varied from a definite designation of a type to the mention merely of one or more (often several) "typical species," which, in the latter case, were usually non-congeneric from the modern standpoint. Besides this, some authors formerly freely accepted genera from pre-Linnæan authors, as Moehring, Ray, Klein, and Gesner, and also felt under no restriction to confine their selection of types to the original elements of a genus. They placed their own interpretations upon the genera of preceding authors, with sometimes little regard for their original constituency, and selected the types for them entirely from their own sense of their fitness. Their action cannot therefore be considered as final in cases where it contravenes universally accepted modern canons of nomenclature. Among such writers in ornithology are Illiger, Vieillot, Vigors, Swainson, Bonaparte, G. R. Gray, and others. At this period of nomenclatural chaos (1800–1842) authors felt free to cancel genera, even their own as well as those of their predecessors and contemporaries, or to transpose them to wholly different groups from those for which they were originally proposed. Although they were in a literal sense 'first revisers,' their revisions can be accepted only in so far as they conform to modern rules of nomenclature. To illustrate by a specific case, G. R. Gray published a 'List of the Genera of Birds' in 1840, in which, naturally, he listed the genera in accordance with his own ideas of their scope and significance, placing in synonymy, or partial synonymy, such as he considered not entitled to recognition. He claimed to be guided rigidly by the rule of priority, and designated a type for each genus he considered entitled to a place in systematic nomenclature. As, however, he took many generic names from Ray, and utilized also those of Moehring, and attributed many to Brisson which Brisson did not use in a generic sense, and took Linnæan genera founded prior to 1758 from 1735–1746), and changed also such as had been previously used in botany, it is impossible to adopt the 'List' *en bloc* as the work of an authoritative first reviser. Yet it is here that many names proposed by Lesson, Boie, Kaup, and Bonaparte, are given definite standing by having species referred to them or by having their types designated. Thus in dealing with Gray's (1840) 'List of Genera,' it is necessary to treat each case on its merits as tested by modern rules of nomenclature. His pre-Linnæan and wrongly attributed Brissonian names must be rejected, his elimination of names on the basis of prior use in botany ignored, and the necessary rectifications substituted where he designated species as types of genera which were not originally included in them. On the other hand, generic names (as some of Lesson's) proposed under vernacular designations, or first published as *nomina nuda* (as some of Bonaparte's), or without definite designation of type (as many of Lesson's,

Swainson's Bonaparte's, etc.), are here first given definite significance, and here find their first proper introduction into nomenclature, on the basis of the work of a 'first reviser.'

The ideal first reviser is the author who, in revising a heterotypic genus, subdivides it into minor groups (genera or subgenera as the case may be), explicitly designates one of the original species as the type of the restricted original genus, and also gives types for each of its subdivisions. Such revision must not only be respected as permanent, but renders the work of any further revision of the groups in question that may prove necessary free from nomenclatural complications.

Unfortunately such clear-cut methods have been rare in systematic zoölogy, and almost wholly wanting prior to about 1840. Before this period other and looser methods prevailed, and it is unusual to find a first reviser whose work can be taken in the sense of a final decision. Yet where, in restricting groups and in designating types, any work stands the test of rules now practically universally accepted[1] it should be taken as final.

Gray's 1840 'List of Genera of Birds' was the beginning of a new era in the matter of types of genera in ornithology. New editions of this work followed in 1841 and 1842, and a much more important edition appeared in 1855[2] in which many of the faults of the 1840 and earlier editions were eliminated. In this edition, he records all of the generic and subgeneric names previously published, so far as they were known to him (very few were omitted), of which 2403 were formally adopted and a type for each designated. Making allowance for the difference in point of view of 1855 as compared with that of fifty years later, it is surprising to find how large a proportion of his type designations have been respected and have become, what are sometimes termed, 'types by general consent.' In most cases of 'types by general consent' they prove to be the types designated by Gray in 1855, many of them running back to Gray's 'List' of 1840, as will be shown in the following pages.

Brissonian Genera.

A few modern systematists protest against the acceptance of Brisson's genera, but on what seem very inadequate grounds. In the first place, Brisson's genera have received almost universal approval for nearly one

[1] That is, excluding the few temperamental kickers who will ignore any rule that is contrary to their personal tastes or preferences.

[2] Catalogue of the Genera and Subgenera of Birds contained in the British Museum. London: Printed by order of the Trustees, 1855. 12 mo. pp. 192.

hundred and fifty years, and having thus become thoroughly assimilated as a part of the modern nomenclature of both mammals and birds, it seems hardly worth while to attempt to eradicate them at the expense of otherwise needless confusion. His great work on birds, in six large quarto volumes, exceptionally well illustrated for the period of publication, bears date 1760, and thus all appeared only two years after the publication of the 10th edition of Linnæus's 'Systema Naturæ,' which was thus not accessible to Brisson during the preparation of his own work. He cites the earlier editions of Linnæus throughout his six volumes, but only begins to cite the 10th edition in the fifth volume, the others doubtless having already been printed.[1] This was of course too late for Brisson to change radically his system of nomenclature, as his great work was written and partly printed before the inauguration of the binomial system. The chief criticism of Brisson's work is the absence of binomiality in his nomenclature, the reason for which is evident.

As an ornithologist and mammalogist Brisson's knowledge was greatly superior to that of his renowned contemporary, Linnæus, or to that of any other author of his time. His treatment of these classes, particularly of the birds, is by far the most elaborate and thorough of any author of that period. His scheme of classification was original, rigidly systematic, and avoided many of the incongruities of grouping so conspicuous in the 'Systema Naturæ,' which work, in point of classification and nomenclature, is superior to Brisson's only in point of binomiality. As a rule, there is less trouble in identifying Brisson's species than those of Linnæus. Brisson had a clear conception of the generic idea, and in many cases his generic groups are far more natural and better limited than those of Linnæus. As evidence of the excellent character of his work, it may be recalled that the British Association Committee in adopting the twelfth edition of the 'Systema Naturæ' (1766) as the starting point for binomial nomenclature made an exception in favor of Brisson's genera, published in 1760, and they have since, as before, been almost universally accepted.

Brisson's genera have one special feature in their favor, under the rule of tautonomy, inasmuch as the first species almost invariably bears the same name as its genus. It is doubtless owing to the recognition of this, until recently, uncodified principle of tautonomy, that the first species, in the case of Brissonian genera, has been recognized as the type.

Brisson's 'Ornithologie' comprises 112 genera, or nearly twice the number (64) given by Linnæus in 1758. He recognized over 1300 species (1316), besides many varieties. In many cases phases of plumage were

[1] Indeed, Brisson states (Supplément, p. 4) that the 10th edition did not reach him till long after the printing of his own work had begun.

mistaken for distinct species, but in this respect he was a no greater sinner than Linnæus, who did the same thing on much the same scale, or than Gmelin, who in 1788 gave names to nearly all of Brisson's species that had not been previously named, as did also Latham. In separating the birds into nearly twice as many genera as did Linnæus, his groups are to this extent the more natural, and avoid many of the grotesque associations of species adopted by Linnæus.

Some of Brisson's genera are preoccupied by the genera of the 1758 edition of the 'Systema Naturæ'; many others are the same, being the same as the Linnæan genera of 1748; of the large number of additional genera nearly all have been adopted by subsequent authors, and to-day are, in a restricted sense, a part of modern nomenclature. A few of these same groups were renamed by Linnæus in 1766; in fact, nearly all of the new genera added by Linnæus in 1766 are Brisson's, with essentially the same limits.

Unfortunately many of Brisson's species names have been attributed to Brisson as generic names, and much of the criticism of Brisson's generic names is due to this misuse of his nomenclature. If only such names as Brisson himself designated as generic are considered as entitled to such recognition, much of the aversion to Brissonian genera becomes groundless.

II. TYPES OF NORTH AMERICAN BIRD GENERA.

In the following pages the genera and subgenera of the present (second) edition of the A. O. U. Check-List of North American Birds and its several Supplements are taken up in the systematic sequence of the Check-List, for the purpose of showing how the types, as now currently accepted, came to be so recognized. The number of the originally contained species is stated, and generally a list of them is given, and in cases where the type was determined by elimination, an attempt is made to show each step of the process. The original place of publication of each genus has been consulted in each case, with five exceptions, noted by placing the citation in marks of quotation. In nearly all of these five the type is obviously fixed by tautonomy.

It having been stated that in a number of instances the types have been erroneously determined, and that consequently a considerable number of the names for generic groups must be changed; and also that in such a revision practically the same number of changes would be required under the 'first species rule' as under 'elimination,' the results are shown for both methods in all cases where the determination of the type is not pro-

vided for by other rules.[1] Generalizations from the data recorded in this systematic statement are deferred until after the facts are presented, and will constitute the closing section of the paper.

In preparing the present paper on the types of North American bird genera, the work was done *de novo*, without reference to the designation of types in the Check-List. It was thus a surprise, on comparing my work, after it was finished, with the Check-List, to find in how few cases different results were reached. In only four cases, (*Cyclorrhynchus, Phaleris, Procellaria, Ceophlœus*) are the current designations of genera changed, and, the genera affected being mostly monotypic, only four species are involved. In some four or five other instances, the type is changed by the action of the rule of tautonomy, or it falls on a different but strictly congeneric species, so that in no case is a change of nomenclature necessary.

In the course of the work, I naturally made frequent use of G. R. Gray's several 'Catalogues' of genera and subgenera, and finally became impressed with the great frequency with which the types of genera and subgenera as designated by him in 1840 to 1855 are still the currently accepted types. The agreement was of such striking frequency that finally after my manuscript was typewritten and revised for publication, I compared my results with Gray's designations and interpolated, as an afterthought, "type as designated by Gray," on the basis of his 1855 'Catalogue,' as it now appears in the following pages, partly as information of general interest, and partly to show what an influence Gray has evidently had, as a 'first reviser,' in fixing genotypes in ornithology, and partly as an offset to the recent demand that all such work must be ignored in order that free license may be accorded to a proposed 'first species rule.'

Of the genera published prior to 1855, the types, as now recognized, are the same for about 90 per cent. of the genera as those indicated as the types by Gray in 1855; in about half of the remaining cases Gray took as types species not originally included in the genus. The discrepancy in the other cases is due to Gray's point of departure for generic names, since in twenty instances he took genera (in the case of those here alone concerned) from Moehring (1752) or from Linnæus prior to 1758 (1735–1748). It is hence surprising that so small a percentage of difference in type designation results.

It is further of interest to note that Gray consistently employed the principle of tautonomy in designating types. In other cases it was obviously

[1] In this connection it may be explained that 'monotypic,' as used in the following pages, is applied to all genera or subgenera which had, at the time of founding, only one species referred to them, and includes, besides actually monotypic groups, a great many others to which many additional species were later referred.

It should also be here stated that the types of the exotic genera cited in the tables of elimination are taken in large part from such standard authorities as the British Museum 'Catalogue of Birds' and Ridgway's 'Birds of North and Middle America,' but many have been verified by reference to the place of original publication.

his rule to take the first species of a generic or subgeneric group as its type, but he refrained from doing this when the first species had already been made the type of some other genus. In other words, he respected the work of his predecessors and exercised his preference for a first species type only when the field was clear for such choice. In case other species in addition to the first species had also been made types of genera, he selected his type from those remaining.

Three evident facts are to be noted in reference to Gray's work as a reviser: (1) the respect shown by later authors for his designated types; (2) his respect for the work of his predecessors in their work of dismembering heterogeneous genera; and (3) his recognition of tautonomy as a proper guide to an author's intentions in founding genera.

We have here also an obvious explanation of how it happens that the type species by elimination, or by action of the priority rule, is so often the first species. We can also derive, from the foregoing, an object lesson applicable to the present agitation for a rigid first species rule, open only to the exception of Linnæan genera. Where the field is clear, or where no species has been designated as the type, it is perfectly proper, and produces no confusion, to take the first species as the type; where, however, a type other than the first species has been designated as the type and is currently recognized as such, it is not only a needless but ruthless innovation to bring in a new rule — a first species rule or any other — the enforcement of which will necessitate the overturning of long-established and universally accepted names.

Family PODICIPETIDÆ.

Genus **Æchmophorus**.

Æchmophorus Coues, Proc. Acad. Nat. Sci. Phila., April, 1862, 229.
2 species, 1 of doubtful status.

1. *occidentalis.*
2. *clarkii,* probably ♀ of No. 1.

Virtually monotypic, with *Podiceps occidentalis* Lawr. as type by designation.

Genus **Colymbus**.

Colymbus Linnæus, Syst. Nat., ed. 10, 1758, 135; part, including 3 of the 4 species. See also *Gavia.*
Colymbus Brisson. Orn., VI, 1760, 33.

Colymbus Linn. contained 4 species, representing 3 genera and 2 orders, as follows:

1. *arcticus,* a species of *Mergus* Briss. (not Linn. = *Gavia* Forster, 1788).
2. *cristatus.*
3. *auritus.*
4. *podiceps,* type of *Podilymbus* Less. 1831.

Nos. 1 and 4 are noncongeneric with each other and with Nos. 2 and 3 which two are congeneric. No. 3 is the type of subgenus *Dytes* Kaup, 1829, leaving No. 2, *cristatus,* as type of the genus (and subgenus) *Colymbus* Linn. as restricted by Brisson.

Colymbus Brisson contained 11 nominal species, representing 6 valid species, all congeneric from the standpoint of the Check-List, except one, as follows:

1, 2, 4 = *cristatus* Linn.
3, 5, 7 = *auritus* Linn.
6 = *nigricollis* Brehm.
8, 10 = *podiceps* Linn., type of *Podilymbus* Less. 1831.
9 = *fluviatilis* Tunst. = *ruficollis* Pallas.
11 = *dominicus* Linn.[1]

Colymbus Brisson contained only Grebes, including Linnæus's three species and three others. Type, by tautonomy, [*Colymbus*] *colymbus* Brisson, the first species=*Colymbus cristatus* Linn.

With the removal of *podiceps,* the remaining five species are congeneric, on the basis of the Check-List and by general usage, but four of them have been made the types of groups commonly ranked as subgenera, but which Sharpe in his 'Hand-List' (Vol. I, 1899, pp. 113–115) treats as full genera. They became types in the following order:

auritus, type of *Dytes* Kaup, 1829 (p. 41).
nigricollis, type of *Proctopus* Kaup, 1829 (p. 49).
cristatus, type of *Lophiathya* Kaup, 1829 (p. 72); was already type of *Colymbus* Briss. 1760.
fluviatilis, type of *Tachybaptus* Reich. 1849.
dominicus, not separable even subgenerically from *fluviatilis.*

In 1760 Brisson removed the Loons from the genus *Colymbus* to a new genus *Mergus* (preoccupied for a genus of Ducks) and retained the Grebes in *Colymbus,* thus separating for the first time these two widely distinct groups. This distinction was recognized by the subsequent early authors, several new names being proposed successively for the Loons, while the Grebes were retained in *Colymbus.* For the Loons, *Mergus* being untenable, Forster proposed *Gavia* in 1788, Lacépède proposed *Urinator* in 1799, and in 1811 Illiger proposed *Eudytes* as a substitute name for *Urinator.* In 1872, Sundevall, in his 'Tentamen' (p. 138), also employed *Eudytes* for

[1] These identifications of Brisson's species are as given by Ogilvy-Grant in Brit. Mus. Cat. Bds., XXVI, 1898, where each is duly synonymized.

the Loons and *Colymbus* for the Grebes, and treated *Podiceps* Latham as a synonym of the restricted (Brissonian) genus *Colymbus*.[1] Pallas, in 1811 (Zoog. Rosso-As., II), again restricted *Colymbus* to the Grebes, while the Loons formed a section, "*A. Cepphi tetradactyli*," of his genus *Cepphus*.

Certain naturalists, more especially the English, have, however, persistently employed *Colymbus* for the Loons and other names for the Grebes, clearly without good reason, possibly following Latham, who, in 1787, proposed *Podiceps* for the Grebes, and adopted *Colymbus* (Latham, *nec* Linn.) for the Loons. German and Scandinavian ornithologists have commonly employed, down to the year 1906, either *Eudytes* or *Urinator* for the Loons, and *Colymbus* for the Grebes. *Colymbus* auct. plur., down to about 1830 or later, = Grebes.

Subgenus **Dytes**.

Dytes Kaup, Skizz. Entw.-Gesch. u. Nat. Syst. Eur. Thierw.,[2] 1829, 41.
2 nominal species, "*Pod. cornutus et arcticus*" = *Colymbus auritus* Linn.

Monotypic, with *Colymbus auritus* Linn. as type.

Subgenus **Podiceps**.

Podiceps Latham, Suppl. Gen. Synop., 1787, 294.
7 species, of which only 4 are valid.

1. *cristatus* Linn., type of *Colymbus* Briss. 1760, and of subgenus *Lophaithya* Kaup, 1829 (p. 72).
2. *urinator* Linn., same as No. 1.
3. *auritus* Linn., type of subgenus *Dytes* Kaup, 1829 (p. 41).
4. *nigricans* Scop., same as No. 3.
5. *ruficollis* = *griseigena* Bodd., type of subgenus *Pedetaithya* Kaup, 1829 (p. 44); strictly congeneric with No. 1.
6. *minutus* = *fluviatilis* Tunst. = *ruficollis* Pall., type of subgenus *Tachybaptus* Reich. 1849.
7. *hebridalis*, same as No. 6.

Type, by elimination, *Podiceps minutus* Lath. (1787) = *Colymbus fluviatilis* Tunstall (1771) = *Colymbus ruficollis* Pallas (1764). As *Podiceps* is untenable for the group so designated in the Check-List, *Tachybaptus* (Reichenbach, 1852, with same type) may be substituted. (*Cf.* Stone, Auk, XXIV, April, 1907, p. 190.)

In the Check-List *Podiceps* was taken from Latham at 1790, instead of from its first place of publication at 1787. In 1790 the genus included 13 species instead of 7 as in 1787, of which 7 are valid. By elimination the

[1] Among other things he says: "Le nom *Colymbus* doit être restitué dans son sens originaire, comme il le fut déjà par Brisson, 1760, et depuis par Illiger, Nitsch, Naumann, Gloger et pl., et les faux Colymbi, de Latham, pourront être nomnés *Eudytes* Ill."— *Sundevall*, Tentamen, 1872, p. LXIV.

[2] This work is often cited as Kaup, 'Natürl. Syst.,' 1829.

type is still *Colymbus minutus* Lath. = *fluviatilis* Tunst., as given in the Check-List.

Latham's "Genus LXXIX, *Podiceps* (*Colymbus* Linn.)" is a substitute name for *Colymbus* Linnæus, and consists of what was left of that group after the Loons were removed from it by *Brisson*. It is therefore an exact synonym of the restricted genus *Colymbus* Brisson of the Check-List. From the modern point of view, Latham had no right to reintroduce, on a later page, the name *Colymbus* ("Genus LXXXVI, *Colymbus*" Latham) as a new genus for the Loons, after making it a synonym of his own genus *Podiceps*, to say nothing of Brisson's having separated the Loons from the Grebes as a distinct genus in 1760, or twenty-seven years before. According to modern usage, in other similar cases, *Podiceps* has no standing, being a pure synonym of an earlier genus.

Genus **Podilymbus**.

Podilymbus Lesson, Traité d'Orn., 1831, 595.

Monotypic, with *Colymbus podiceps* Linn. as type.

Family GAVIIDÆ.

Genus **Gavia**.

Colymbus Linnæus, Syst. Nat., ed. 10, 1758, 135; part, 1 only of the 4 species.
Mergus Brisson, Orn. VI, 1760, 104; preoccupied.
Gavia Forster, Enchirid. Hist. Nat., 1788, 38.

Type, as fixed by the A. O. U. Check-List Committee in 1886, *Colymbus imber* Gunn.

Forster's genera in the 'Enchiridion' rest on diagnoses alone, no species being cited as belonging to them. In the case of the Loons and Grebes, the diagnoses place the Grebes in the genus *Colymbus* and the Loons in a new genus *Gavia*, the first tenable generic name for the group (in place of *Mergus* Briss. 1760).

Gavia has been objected to on the ground that no species were referred to it; the diagnosis, however, excludes all species but the Loons, and the several species of Loons are all congeneric. Forster makes three genera for diving birds, one for the Grebes (*Colymbus*), one for the Auks, as then known (*Uria*), and one for the Loons (*Gavia*), the diagnoses of which are unequivocal and definitive, as follows:[1]

"74. *Colymbus*, rostrum subulatum lateribus compressiusculum. Pedes *lobati*, Tibiæ *postice carinato-serratæ*.

[1] In this transcript the contrasting features of the three groups are italicised.

"75. *Uria*, rostrum subulatum, compressum. Pedes *palmati, tridactyli*, tibiis *postice muticis* [truncated or rounded, in contrast with the posteriorly strongly carinate tarsi in the other two groups].

"76. *Gavia*, rostrum subulatum, compressum. Pedes *palmati, tetradactyli.*"

Gavia appears to have been again first used in a generic sense by Goldfuss in 1820 (Handb. der Zool., I, p. 208) for a group of Gulls (*Larus marinus* Linn. and *L. nævius* Linn.) and in this sense is a synonym of the restricted genus *Larus* Linn. In order to provide for the determination of the type in the case of genera resting solely on a diagnosis, the revised (as yet unpublished) A. O. U. Code has a ruling to the effect that the type in such cases is to be determined by applying the usual rules "to the genus as adopted by the first subsequent author who referred species to it," to which evidently should be added: *provided it was not used for species that do not conform to the diagnosis. The name is preoccupied for later use for species which are obviously not pertinent to the original diagnosis.* Thus *Gavia* Goldfuss is a new genus, having nothing whatever to do with *Gavia* Forster, the species referred to it not belonging to even the same order of birds. It is therefore merely a new genus under a preoccupied name.

Family ALCIDÆ.

Genus **Lunda.**

Lunda Pallas, Zoog. Rosso-As., II, 1811, 363.

3 noncongeneric species.

1. *cirrhata.*
2. *arctica*, type of *Fratercula* Briss. 1760.
3. *psittacula*, type of *Phaleris* Less. 1820, and of *Cyclorrhynchus* Kaup, 1829.

Type, as designated by Gray (1840) and by elimination, *Alca cirrhata* Pallas, 1769, the first species.

Genus **Fratercula.**

Fratercula Brisson, Orn., VI, 1760, 81.

Monotypic, with [*Fratercula*] *fratercula* Briss. = *Alca arctica* Linn. as type; also tautonymic.

Genus **Cerorhinca.**

Cerorhinca Bonaparte, Ann. N. Y. Lyc. Nat. Hist., 1828, 427.

Monotypic, with *C. occidentalis* Bonap. = *Alca monocerata* Pall. as type.

Genus **Ptychoramphus.**

Ptychoramphus Brandt, Bull. Acad. St. Pétersb., II, 1837, 347.

Monotypic, with *Uria aleutica* Pall. as type.

Genus **Cyclorrhynchus.**

Cyclorrhynchus KAUP, Skizz. Entw.-Gesch. Eur. Thierw., 1829. 155, 195.

Monotypic, with *Alca psittacula* Pall. as type.

Consequently *Cyclorrhynchus* is a synonym of *Phaleris* Temm., 1820, q. v.

Genus **Simorhynchus.**

Simorhynchus MERREM, Ersch. and Gruber's Encycl., Section I, Vol. II, 1819, 405.
2 noncongeneric species.

1. *cristatus.*
2. *psittacula,* type of *Phaleris* Temm. 1820.

Type, as designated by Gray (1855) and by elimination, *Simorhynchus cristatus* = *Alca cristatella* Pall. It is hence a synonym of "*Æthia* ou *Æthya* Dumont," 1816 (Dict. des Sci. nat., I, 1816, suppl., 71), based exclusively on the same two species (*Cf.* Stone, Auk, XXIV, April, 1907, p. 190). *Æthia* will thus replace *Simorhynchus* in the Check-List.

Subgenus **Phaleris.**

Phaleris TEMMINCK, Man. Orn., I, 1820, p. cxii.

"Esp. (*Alca psittacula* adulte, et *tetracula,* jeune) — (*Cristatella* adulte, et *pygmea,* jeune), les deux espèces connues du genre." Hence:

1. *psittacula* + *tetracula* juv. = *Alca psittacula* Pall.
2. *cristatella*? = *cristatella* Pallas, type of *Æthia* Dumont, 1816, and of *Simorhynchus* Merrem, 1819.
3. *pygmea*? = *Alca pygmæa* Gmel., congeneric with No. 2.

Type, as designated by Gray (1840) and by elimination, *Alca psittacula* Pallas, the first species. (Not *Alca pygmæa* Gmel., as given in the A. O. U. Check-List, which species requires a new generic name, which is supplied by Mr. Stone as *Alcella.* (*Cf.* Stone, Auk, XXIV, April, 1907, p. 197).

Subgenus **Ciceronia.**

Ciceronia REICHENBACH, Syst. Av., 1852, p. iii.

Monotypic, with *Phaleris nodirostris* Bonap. = *Uria pusilla* Pall. as type.

Genus **Synthlyboramphus.**

Synthlyboramphus BRANDT, Bull. Acad. St. Pétersb., II, 1837, 347.
2 congeneric species.

1. *antiquus.*
2. *temminckii* = *Uria wumizusume* Temm.

Type, as designated by Gray (1840) and by general consent, *Alca antiqua* Gmel., the first species.

Genus **Brachyramphus.**

Brachyramphus Brandt, Bull. Acad. St. Pétersb., II, 1837, 346.
4 species, representing two modern genera.

1. *marmoratus.*
2. *wrangeli,* same as No. 1.
3. *brachyptera* = *Alca antiqua* Gmel., a species of *Simorhynchus* Brandt, described one page later in same paper.
4. *kittlitzii* = *brevirostris* Vigors, 1828, congeneric with No. 1.

Type, as designated by Gray (1840) and by general consent, *Colymbus marmoratus* Gmel., the first species.

Genus **Cepphus.**

Cepphus Pallas, Spic. Zool., V, 1769, 33.

Monotypic, with *Cepphus lacteolus* Pall. sp. nov. = *Alca grylle* Linn. 1766, as type.

Genus **Uria.**

Uria Brisson, Orn., VI, 1760, 70.

Type, by tautonomy, [*Uria*] *uria* Briss. = *Colymbus troile* Linn., the first species.

Genus **Alca.**

Alca Linnæus, Syst. Nat., ed. 10, I, 1758, 130.
6 species, representing 4 modern genera.

1. *torda.*
2. *impennis,* type of *Plautus* Brünn. 1772.
3. *arctica,* type of *Fratercula* Briss. 1760.
4. *lomvia,* a species of *Uria* Briss. 1760.
5. *grylle,* a species of *Uria* Briss. 1760.
6. *alle,* type of *Alle* Link, 1806.

Type, by elimination, *Alca torda* Linn., the first species.

Genus **Plautus.**

Plautus Brünnich, Zool. Fund., 1772, 78.

Monotypic, with the Brillefuglen = *Alca impennis* Linn. as type. *Plautus* is based on an unmistakable diagnosis, with the addition, in the Danish translation on the opposite page, of the Danish vernacular name for the Garefowl or Great Auk.

Genus **Alle.**

"*Alle* Link, Beschr. Nat. Samml. Univ. Rostock, I, 1806, 17." [Not seen.]

Type, by tautonomy, *Alca alle* Linn.

Family STERCORARIIDÆ.

Genus **Megalestris.**

Megalestris Bonaparte, Cat. Coll. Parzudarki, 1856, 11.

Monotypic, with *Megalestris catarrhactes* = *Catharacta skua* Brünn. as type.

Genus **Stercorarius.**

Stercorarius Brisson, Orn. VI, 1760, 149.

Type, by tautonomy, [*Stercorarius*] *stercorarius* Briss. = *Larus parasiticus* Linn. The group (3 species) consisted only of the Jaeger Gulls.

Family LARIDÆ.

Genus **Pagophila.**

Pagophila Kaup, Skizz. Entw.-Gesch. Eur. Thierw., 1829, 69, 196.

Monotypic, with *Larus eburneus* Phipps = *L. albus* Gunn. as type. Replaces *Gavia* Boie, 1822 (twice preoccupied), formerly employed in the Check-List.

Genus **Rissa.**

Rissa Stephens, Gen. Zool., XIII, i, 1825, 180.

Monotypic, with *Rissa brunnichii* = *Larus tridactylus* Linn. 1758 (= *L. rissa* et *tridactylus* Linn. 1766) as type; also autonymic.

Genus **Larus.**

Larus Linnæus, Syst. Nat., ed. 10, I, 1758, 136.
6 species, representing 3 (or 4) modern genera.

1. *tridactylus*, type of *Rissa* Stephens, 1825.
2. *canus*.
3. *marinus*, type of *Gavia* Goldfuss, 1820, of *Leucus* Kaup, 1829, and of *Dominicanus* Bruch, 1853.
4. *fuscus*, type of *Clupeilarus* Bonap. 1857.
5. *atricilla*, type of *Chroicocephalus* Eyton, 1837, and of some half-dozen other later "genera" or subgenera.
6. *parasiticus*, type of *Stercorarius* Briss. 1760.

Type, as designated by Gray (1855), by elimination, and by general consent, *Larus canus* Linn., the second species.

Some 25 to 30 or more generic or subgeneric names have been based on species now currently referred to *Larus*; *canus* is the only one of the original six species that has not been made the basis of a generic or a subgeneric name, some of them several times. Species 2, 3, 4, and 5 are currently treated as congeneric; 3 and 4 (congeneric with 2) having been

made types (as also has the later described and strictly congeneric *L. argentatus* Brünn.), should take out *canus* with them. So that, strictly considered nothing has been left in the original genus *Larus*. The fact remains, however, that all of these 30 or more genera are now currently treated as synonyms of *Larus*, which would leave *canus* available as the type of *Larus*, as commonly recognized.

Genus **Rhodostethia**.

Rhodostethia Macgillivray, Man. Brit. Orn., II, 1842, 252.

Monotypic, with *Larus rosea* Macgill. as type.

Genus **Xema**.

Xema Leach, Ross's First Voy. Disc., App., 1819, p. lvii.

Monotypic, with *Larus sabinii* Leach as type.

Genus **Creagrus**.

Creagrus Bonaparte, Naumannia, 1854, 211, 214.

Monotypic, and type designated (p. 214) as "*fuscatus* [sic] Neboux, nec Lesson" = *Larus furcatus* Neboux.

Genus **Gelochelidon**.

Gelochelidon Brehm, Isis, 1830, 994.
3 nominal species, = 1 valid species.

1. *G. balthica* Brehm = *Sterna nilotica* Hasselq. 1762 = *Sterna anglica* Montag. 1813.
2. *G. agraria* Brehm, same as No. 1.
3. *G. meridionalis* Brehm, same as No. 1.

Monotypic, with *Gelochelidon balthica* Brehm = *Sterna nilotica* Hasselq. as type.

Genus **Thalasseus**.

Thalasseus Boie, Isis, 1822, 563.
3 noncongeneric species.

1. *caspia.*
2. *cantiaca*, type of *Actochelidon* Kaup, 1829.
2. *anglica*, type of *Gelochelidon* Brehm, 1830.

Type, as designated by Gray (1840) and by elimination, *Sterna caspia* Pall., the first species.

Genus **Actochelidon**.

Actochelidon Kaup, Skizz. Entw.-Gesch. Eur. Thierw., 1829, 31.

Monotypic, with *Sterna cantiaca* Gmelin as type.

Genus **Sterna**.

Sterna Linnæus, Syst. Nat., ed. 10, I, 1758, 137.
3 noncongeneric species.
1. *stolida*, type of *Anous* Stephens, 1826.
2. *hirundo*.
3. *nigra*, type of *Hydrochelidon* Boie, 1822.

Type, by elimination, *Sterna hirundo* Linn., the second species, as designated by Gray (1840) and as since commonly recognized.

Subgenus **Sternula**.

Sternula Boie, Isis, 1822, 563.

Monotypic, with *Sterna minuta* Linn. as type.

Genus **Onychoprion**.

Onychoprion Wagler, Isis, 1832, 277.

Monotypic, with *Sterna serrata* Wagler = *Sterna fuliginosa* Gmel. as type.

Haliplana Wagler, Isis, 1832, 1224, is a synonym, being monotypic, with *Haliplana fuliginosa* (= *Sterna fuliginosa* Gmel.) as type.

Genus **Hydrochelidon**.

Hydrochelidon Boie, Isis, 1822, 563.
2 congeneric species.
1. *nigra*; 2, *leucoptera*.

Type, *Sterna nigra* Linn., the first species, as designated by Gray (1855) and by general consent.

Genus **Anous**.

Anous Stephens, Gen. Zool., XIII, i, 1826, 139.
4 nominal species, two of them phases of plumage of the same species.
1. *niger* = *Sterna stolida* Linn.
2. *fuscatus* = *Sterna fuscata* Linn. = *stolida* Linn.
3. *plumbea* Wils. a species of *Hydrochelidon* Boie, 1822.
4. ?*spadicea*, based on a young bird of doubtful identity.

Type, as designated by Gray (1840) and by elimination, *Anous niger* = *Sterna stolida* Linn., the first species.

Family RHYNCHOPIDÆ.

Genus **Rhynchops**.

Rhynchops Linnæus, Syst. Nat., ed. 10, I, 1758, 138.
2 species, *nigra* and *fulva*, the latter not identifiable but supposed to be the same as *nigra*.

Type, *R. nigra* Linn. Virtually monotypic.

Family DIOMEDEIDÆ.

Genus **Diomedea**.

Diomedea Linnæus, Syst. Nat., ed. 10, I, 1758, 132.
2 species, belonging to different orders.

1. *exulans*.
2. *demersus*, type of *Spheniscus* Briss. 1760.

Type, as designated by Gray (1840) and by elimination, *Diomedea exulans* Linn., the first species.

Genus **Thalassogeron**.

Thalassogeron Ridgway, Bd., Br. and Ridgw., Water Birds N. Am., II, 1884, 357.

Monotypic, with *Diomedea culminata* Gould as type by designation; to replace *Thalassarche* Reich. 1852 (preoccupied), with same type.

Genus **Phœbetria**.

Phœbetria Reichenbach, Syst. Av., 1852, p. v.

Monotypic, with *Diomedea fuliginosa* Gmel. as type.

Family PROCELLARIIDÆ.

Genus **Ossifraga**.

Ossifraga Hombron & Jacquinot, Comp. Rend., XVIII, 1844, 356.

Monotypic, with *Procellaria gigantea* Gmel. as type by designation.

Preoccupied by *Ossifraga* Wood, 1835, and to be replaced by *Macronectes* Richmond, 1905. (*Cf.* Richmond, Proc. Biol. Soc. Wash., XVIII, 1905, p. 76.)

Genus **Daption**.

Daption Stephens, Gen. Zool., XIII, i, 1825, 239.
8 species, representing 7 modern genera.

1. *capensis*.
2. *antarcticum*, type of *Thalassœca* Reich. 1852.
3. *niveum*, type of *Pagodroma* Bonap. 1855.
4. *desolatum*, type of *Pseudoprion* Coues, 1866.
5. *gelidum*, not certainly identifiable.
6. *griseum*, a species of *Puffinus* Briss. 1760.
7. *album*, a species of *Æstrelata* Bonap. 1855.
8. *fuliginosum*, a species of *Oceanodroma* Reich. 1852.

Type, as designated by Gray (1840) and by elimination, *Procellaria capensis* Linn., the first species.

Genus **Fulmarus**.

Fulmarus Stephens, Gen. Zool., XIII, i, 1826, 233.

3 species, representing 3 genera.

1. *glacialis.*
2. *antarcticus,* type of *Thalassœca* Reich. 1852.
3. *giganteus,* type of *Ossifraga* Hombr. & Jacq. 1844.

Type, as designated by Gray (1855) and by elimination, *Procellaria glacialis* Linn., the first species.

Genus **Priocella.**

Priocella Hombron & Jacquinot, Comp. Rend., XVIII, 1844, 357.

Monotypic, with *Priocella garnotii* sp. nov. as type = *Procellaria glacialoides* Smith.

Genus **Puffinus.**

Puffinus Brisson, Orn., VI, 1760, 131.

Type, by tautonomy, [*Puffinus*] *puffinus* Briss. = *Procellaria puffinus* Brünn. 1764, and Linn. 1766 = *Procellaria* (*Nectris*) *anglorum* Kuhl, 1820, and of recent authors.

Genus **Priofinus.**

Priofinus Hombron & Jacquinot, Comp. Rend., XVIII, 1844, 355.

2 noncongeneric species.

1. *cinerea.*
2. *œquinoctialis,* type of *Majaqueus* Reich. 1852.

Type, as designated by Gray (1855) and by elimination, *Procellaria cinerea* Gmel. the first species.

Genus **Æstrelata.**

Æstrelata Bonaparte, Consp. Av., 1856, 188.

4 congeneric species.

1. *diabolica* (l'Herm.) = *hasitata* Kuhl.
2. *desolata* (Gm.), a species of *Prion* Lacép. 1799.
3. *inexpectata* (Forst.), congeneric with No. 1.
4. *leucocephala* (Forst.) = *lessoni* Garnot, congeneric with No. 1.

Type, as designated by Coues (1866) and by general consent, *Procellaria hasitata* Kuhl, the first species.

Genus **Bulweria.**

Bulweria Bonaparte, Cat. Metod. Ucc. Eur., 1842, 81.

Monotypic, with *Procellaria bulweri* Jard. & Selby as type; hence also tautonymic.

Genus **Halocyptena.**

Halocyptena Coues, Proc. Acad. Nat. Sci. Phila., March, 1864, 78.

Monotypic, with *Halocyptena microsoma* Coues, sp. nov. as type.

Genus **Procellaria.**

Procellaria Linnæus, Syst. Nat., ed. 10, I, 1758, 131.
3 species, representing 3 genera.

1. *pelagica*, type of *Thalassidroma* Vigors, 1825.
2. *æquinoctialis*, type of *Majaqueus* Reich. 1852.
3. *capensis*, type of *Daption* Steph. 1826.

Type, as designated by Gray (1840, not 1855) and by elimination, *Procellaria æquinoctialis* Linn., the second species; not *P. pelagica* Linn. as given in the Check-List.

Thalassidroma (monotypic) will thus replace *Procellaria* of the Check-List, and *Procellaria will replace Majaqueus.*

Genus **Oceanodroma.**

Oceanodroma Reichenbach, Syst. Av., 1852, p. iv.

Monotypic, with *Procellaria furcata* Gmel. as type.

Genus **Oceanites.**

Oceanites Keyserling & Blasius, Wirb. Eur., I, 1840, xciii, 131, 238.

Type, by tautonomy, "*O. wilsoni* Bonap." = *Procellaria oceanica* Kuhl.

Genus **Fregetta.**

Fregetta Bonaparte, Compt. Rend., XLI, 1855, 1113.

Type, by designation, *Thalassidroma leucogastra* Gould = *Procellaria grallaria* Vieill.

Genus **Pelagodroma.**

Pelagodroma Reichenbach, Syst. Av., 1852, p. iv.

Monotypic, with *Procellaria marina* "Forst." (= Lath.) as type.

Family PHAËTHONTIDÆ.

Genus **Phaëthon.**

Phaëthon Linnæus, Syst. Nat., ed. 10, I, 1758, 134.
2 species, belonging to two widely different orders.

1. *æthereus.*
2. *demersus*, type of *Catarractes* Briss. 1760.

Type, as designated by Gray (1840) and by elimination, *Phaëthon æthereus* Linn.

Family SULIDÆ.

Genus **Sula.**

Sula Brisson, Orn. VI, 1760, 495.
7 species (only 4 of them valid), representing 2 modern genera (*Sula* and *Fregata*).

Type, by tautonomy, [*Sula*] *sula* Briss. = *Pelecanus sula* Linn., the first species.

Subgenus **Dysporus**.

Dysporus Illiger, Prodr., 1811, 279.
2 congeneric species, representing two modern subgenera.
1. *Pelecanus sula* Linn., type of *Sula* Briss. 1760.
2. *Pelecanus bassanus* Linn.

Type, by elimination, *Pelecanus bassanus* Linn.

By the first species rule *Dysporus* is a synonym of *Sula*, having the same first species. If necessary to separate *Pelecanus bassanus* from the *P. sula* group, respecting which usage differs, *Dysporus* is tenable, under elimination, as a subgeneric name for *P. bassanus*. *Morus* Vieill. 1816, recently brought forward to replace *Dysporus* (*cf.* Stone, Auk, XXIV, April, 1907, p. 194), is purely a substitute name for *Sula*, as shown by Vieillot's use of it a few months later in another connection (Nouv. Dict. d'Hist. Nat., nouv. éd., XII, 1817, pp. 35–41), where he included under it all the Gannets then known.

Family ANHINGIDÆ.

Genus **Anhinga**.

Anhinga Brisson, Orn., VI, 1760, 476.

Monotypic, with [*Anhinga*] *anhinga* Briss. (ex *Anhinga* Marcgrave) = *Plotus anhinga* Linn. as type; also tautonymic.

Family PHALACROCORACIDÆ.

Genus **Phalacrocorax**.

Phalacrocorax Brisson, Orn., VI, 1760, 511.
2 congeneric species.

Type, by tautonomy, [*Phalacrocorax*] *phalacrocorax* Briss. = *Pelecanus carbo* Linn.

Subgenus **Compsohalieus**.

Compsohalieus Ridgway, Bd., Br. & Ridgw., Water Bds. N. Am., II, 1884, 145.

Monotypic, with *Carbo penicillatus* Brandt as type.

Subgenus **Urile**.

Urile Bonaparte, Consp. Av., II, 1855, 175.
3 species, 2 noncongeneric, 1 not identifiable.
1. *bicristatus*.
2. *penicillatus*, type of *Compsohalieus* Ridgw. 1884.
3. *egretta*, not identifiable.

Type, by elimination, *Phalacrocorax bicristatus* Pall. = *Pelecanus urile* Gmel. (part); also tautonymic.

Family PELECANIDÆ.

Genus **Pelecanus**.

Pelecanus Linnæus, Syst. Nat., ed. 10, I, 1758, 132.

5 species, representing 4 modern genera.

1. *onocrotalus*, type of *Onocrotalus* Brisson, 1760.
2. *aquila*, type of *Fregata* Cuv. 1799.
3. *carbo*, type of *Phalacrocorax* Briss. 1760.
4. *bassanus*, a species of *Sula* Briss. 1760, and type (by elimination) of subgenus *Dysporus* Ill. 1811.
5. *piscator*, a species of *Sula* Briss. 1760, and type of *Piscatrix* Reich. 1850.

Pelecanus of Linnæus comprised four distinct groups: (1) Pelicans; (2) Frigate Birds; (3) Cormorants; (4) Gannets. Brisson gave generic names to three of them, in the following order: (1) *Sula*, in which was included the Frigate Bird under the name [*Sula*] *fregata*; (2) *Phalacrocorax*, for the Cormorants; (3) *Onocrotalus*, for the Pelicans. *Onocrotalus*, being the last of the three groups in the order of treatment, may be construed as a synonym of *Pelecanus* Linn. the type of which is obviously the only species given by Linnæus of the modern genus *Pelecanus*, namely, *Pelecanus onocrotalus* Linn., as designated by Gray (1840–1855). Otherwise the type of *Pelecanus* would be *P. aquila*, as *Fregata* is tenable as a generic name only from Cuvier (or Lacépède), 1799.

Subgenus **Cyrtopelicanus**.

Cyrtopelicanus Reichenbach, Syst. Av., 1852, p. vii.

Monotypic, with *Pelecanus trachyrhynchus* Lath. = *P. erythrorhynchus* Gmel. as type.

Subgenus **Leptopelicanus**.

Leptopelicanus Reichenbach, Syst. Av., 1852, p. vii.

Monotypic, with *Pelecanus fuscus* Gmel. = *P. onocrotalus β occidentalis* Linn. as type.

Family FREGATIDÆ.

Genus **Fregata**.

Fregata Cuvier, Leç. d' Anat. Comp., I, 1799, tab. ii.

Monotypic, with the "Frégate" = *Pelecanus aquilus* Linn. as type.

In the second edition of the A. O. U. Check-List the genus is wrongly taken from Brisson who did not use it in a generic sense, but only as a species name for species 6 of his genus *Sula* namely [*Sula*] *fregata*. The genus was properly accredited to Cuvier in the first edition of the Check-List. *Fregata* has the same basis from Lacépède (1799) and Duméril (1806).

Family ANATIDÆ.

Genus **Merganser**.

Merganser Brisson, Orn. VI, 1760, 230.

An exact synonym of *Mergus* Linn. 1758, containing the same four species and nothing else.

Genus **Lophodytes**.

Lophodytes Reichenbach, Syst. Av., 1852, p. ix.

Monotypic, with *Mergus cucullatus* Linn. as type.

Genus **Mergus**.

Mergus Linnæus, Syst. Nat., ed. 10, 1758, 129.

5 species, representing 3 modern genera.

1. *cucullatus*, type of *Lophodytes* Reich. 1852.
2. *merganser*, congeneric with No. 3.
3. *serrator*, type of *Serrator* Sprüngli, 1784 (*cf.* Richmond, *l. c.*).
4. *albellus*, type of *Mergellus* Selby, 1840.
5. *minutus*, the same as No. 4.

Type, by virtual tautonomy, *Mergus merganser* Linn., the second species. Dr. Richmond has proposed (Proc. U. S. Nat. Mus., XXIV, 1902, p. 715) to replace *Mergus* Linn. with *Serrator* Sprüngli, 1784. The name *merganser* (= *mergus* + *anser*) is sufficiently tautonymic to warrant taking this species as the type of *Mergus*, thus avoiding otherwise necessary changes. Both by elimination and the first species rule *cucullatus* would be the type.

Genus **Anas**.

Anas Linnæus, Syst. Nat., ed. 10, 1758, 122.

39 species (of which 7 are invalid), representing about 25 modern genera.

1. *cygnus*, type of *Cygnus* Bechst. 1803.
2. *cygnoides*, type of *Cygnopsis* Brandt, 1836.
3. *tadorna*, type of *Tadorna* Flem. 1822.
4. *spectabilis*, often considered congeneric with No. 12, type of subgenus *Erionetta* Coues, 1884.
5. *fusca*, type of subgenus *Melanitta* Boie, 1822.
6. *nigra*, type of *Oidemia* Fleming, 1822.
7. *anser*, type of *Anser* Briss. 1760.
8. *erythropus*, a species of *Anser* Briss. 1760.
9. *canadensis*, congeneric with No. 11.
10. *cærulescens*, a species of *Chen* Boie, 1822.
11. *bernicla*, type of *Branta* Scop. 1769.
12. *mollissima*, type of *Somateria* Leach, 1819.
13. *moschata*, type of *Cairina* Flem. 1822.
14. *bahamensis*, type of *Pœcilonetta* Eyton, 1838.
15. *albeola*, type of *Bucephala* Baird, 1858 (preoccupied) = *Charitonetta* Stejn. 1885.

16. *clypeata*, type of *Spatula* Boie, 1822.
17. *platyrhynchos*, same as No. 16.
18. *strepera*, type of *Chaulelasmus* Bonap. 1838.
19. *bucephala*, same as No. 15, ♂.
20. *clangula*, type of *Clangula* Oken, 1817 (*cf.* Stone, Auk, 1907, p. 191).
21. *rustica*, same as No. 15, ♀.
22. *perspicillata*, type of *Pelionetta* Kaup, 1829.
23. *glaucion*, same as No. 20, ♀.
24. *penelope*, type of *Penelope* Steph. 1824.
25. *acuta*, type of *Dafila* Steph. 1824.
26. *hyemalis*, type of *Harelda* Steph. 1824.
27. *ferina*, a species of *Nyroca* Flem. 1822.
28. *querquedula*, type of *Querquedula* Steph. 1824.
29. *crecca*, type of *Nettion* Kaup, 1829.
30. *histrionica*, type of *Histrionicus* Less. 1828.
31. *minuta*, same as No. 30.
32. *circia*, same as No. 28.
33. *autumnalis*, a species of *Dendrocygna* Swains. 1837.
34. *boschas*, type of *Boschas* Swains. 1831.
35. *adunca*, same as No. 34, domesticated.
36. *galericulata*, type of *Dendronessa* Swains. 1831.
37. *sponsa*, type of *Aix* Boie, 1828.
38. *arborea*, a species of *Dendrocygna* Swains. 1837.
39. *fuligula*, type of *Fuligula* Steph. 1824 = *Marila* Oken, 1817 (apud Stone, *l. c.*).

Type, as designated by Gray (1840) and also by general consent for nearly a century, *Anas boschas* Linn., the thirty-fourth species.

The genus *Anas* Linn. 1758, affords an excellent illustration of the difficulties that may sometimes arise in determining types by the so-called elimination method where a genus originally contained a large number of species. *Anas* had originally 39 species, of which 7 were duplications, leaving 32 actual species, every one of which, in the course of the next hundred years, became the type of or congeneric with the type of some other genus or subgenus, or in some cases of more than one. In 1831, Swainson (Faun. Bor.-Am., II, 1831, pp. 442–444) proposed a "subgenus" *Boschas* for a group of heterogeneous species, including *Anas domestica* (= *boschas* Linn.), which, by the rule of tautonomy, would be the type; at the same time (p. 439) Swainson restricted *Anas* Linn. to *Anas clypeata*, already the type of *Spatula* Boie, 1822. Subsequently four now currently recognized genera, and a number of subgenera, were based on other species of the original genus *Anas* remaining in it after *Anas boschas* was removed. To take either of these as type would transfer *Anas* to most unfamiliar and unwelcome associations, inasmuch as *Anas boschas* and its immediate affines have been for nearly a century considered by ornithologists in general as constituting the restricted genus *Anas*. Repeatedly, prior to 1831,

boschas was definitively assigned as the type of *Anas,* a fact that must be considered in dealing with Swainson's subgenus *Boschas.* In other words, it is proper to consider *Boschas* as a pure synonym of the restricted genus *Anas,* thus freeing the case of complications.

(By the first species rule the type of *Anas* would be *Anas cygnus* Linn., the Common Swan.)

Genus **Chaulelasmus.**

Chaulelasmus Bonaparte, Geogr. and Comp. List, 1838, 56.

Monotypic, with *Anas strepera* Linn. as type. To replace *Chauliodus* Swains., 1831, preoccupied, with same type.

Genus **Mareca.**

Mareca Stephens, Gen. Zool., XII, ii, 1824, 130.

8 species, representing 4 modern genera.

1. *fistularis* = *Anas penelope* Linn.
2. *melanura,* of doubtful identification; commonly referred, with a ?, to No. 1.
3. *pœcilorhyncha,* a species of *Anas, sens. stric.*
4. *americana,* congeneric with No. 1.
5. *bahamensis,* type of *Pœcilonetta* Eyton, 1838.
6. *brasiliensis,* a species of *Nettion* Kaup, 1829.
7. *capensis,* a species of *Nettion* Kaup, 1829.
8. *glocitans,* a hybrid, probably of Widgeon and Teal.

Type, as designated by Gray (1840) and by elimination, *Mareca fistularis* Steph. = *Anas penelope* Linn., the first species; also figured as the typical representative of the genus.

Genus **Nettion.**

Nettion Kaup, Skizz. Entw.-Gesch. Eur. Thierw., 1829, 95, 196.

Monotypic, with *Anas crecca* Linn. as type.

Genus **Querquedula.**

Querquedula Stephens, Gen. Zool., XII, ii, 1824, 142.

8 species (3 of doubtful identification), representing 2 or 3 modern genera.

1. *circia* (Linn. 1758, No. 28 = *Anas querquedula* Linn. 1758, No. 32).
2. *crecca,* type of *Nettion* Kaup, 1829.
3. *carolinensis,* a species of *Nettion* Kaup, 1829.
4. *discors,* congeneric with No. 1.
5. *formosa,* a species of *Nettion* Kaup, 1829.
6. *hina,* indeterminable; variously identified.
7. *manillensis,* doubtfully referred by Salvadori (Cat. Bds. Brit. Mus., XXVII, 1895, 147) to *Dendrocygna viduata* (Linn.).
8. *novæ-hispaniæ,* doubtfully referred to No. 4.

Type, by elimination, *Anas circia* Linn., which is figured as the typical representative of the genus; also type by tautonomy.

According to Mr. Stone (Auk, XXIV, April, 1907, p. 191), *Querquedula* will date from S. G. Gmelin, 1770 (Reise durch Russland, I, 1770, p. 70), with the same type. An examination of Gmelin's work shows that *Querquedula* is not used by Gmelin in either a taxonomic or in a proper nomenclatural sense. "Querquedula prima" and "Querquedula secunda" are simply Willughby's names for these ducks, taken from Linnæus's 'Fauna Suecica,' coupled with the Linnæan diagnoses, in place of citing, as he often does in other cases, only a Linnæan diagnosis in place of a Linnæan binomial. It is a case perfectly parallel with that of *Gavia*, in the same work, discussed by me in 'The Auk' for 1901 (XVIII, p. 270). Both before and after the use of "Querquedula" on p. 70, Gmelin uniformly employs *Anas* as the generic name of all the ducks he has occasion to mention. Gmelin's technical names, throughout his 'Reise,' lack consistency, being in part diagnoses from the 'Fauna Suecica,' in part Linnæan binomials, and in part names from Brisson, Willughby, and Gesner.

Genus **Casarca**.

Casarca Bonaparte, Geogr. and Comp. List, 1838, 56.

Monotypic, with *Anas rutila* Pall. as type.

Genus **Spatula**.

Spatula Boie, Isis, 1822, 564.

Monotypic, with *Anas clypeata* Linn. as type.

Genus **Dafila**.

Dafila Stephens, Gen. Zool., XII, ii, 1824, 126.

Monotypic, with *Dafila caudacuta* Steph. = *Anas acuta* Linn. as type.

Genus **Aix**.

Aix Boie, Isis, 1828, 329.

3 species, first and third sometimes regarded by recent authorities as congeneric (*cf.* Salvadori, Cat. Bds. Brit. Mus., XXVII, 1895, 73), or all as noncongeneric (*cf.* Sharp, Hand-list, I, 1899, pp. 209, 218).

1. *galericulata*, type of *Dendronessa* Swains. 1831.
2. *falcaria* (Pall. 1776, *falcata* Georgi, 1775), type of *Eunetta* Bonap. 1856.
3. *sponsa*.

Type, as designated by Gray (1840) and by elimination, *Anas sponsa* Linn., the last species.

[In this connection must be considered *Dendronessa* Swains. 1831, and *Lampronessa* Wagler, 1832.

Dendronessa Swainson, Faun. Bor. Amer., II, 1831, 446, 497.
2 species.
1. *sponsa*, p. 466; declared to be "aberrant" on p. 497.
2. *galericulata*, designated as the type, p. 497.

Lampronessa Wagler, Isis, 1832, Heft 3, 282.
2 species.
"Species: *Anas sponsa* Linn.— *Anas galericulata* Linn."

Lampronessa is a synonym of *Dendronessa* Swains. 1831, containing the same species, in the same order, and no others. *Dendronessa* does not come under the 'first species' rule, the type having been designated by the founder; but by the application of the first species rule to *Aix*, *Dendronessa* becomes a synonym of *Aix*, and a new name would be required for the Wood Duck (*Anas sponsa* Linn.) by those who do not consider it congeneric with the Mandarin Duck (*Anas galericulata* Linn.), for which *Dendronessa* Swains. would be otherwise available.]

Genus **Netta**.

Netta Kaup, Skizz. Entw.-Gesch. Eur. Thierw., 1829, 102, 196.

Monotypic, with *Anas rufina* Pallas as type.

Genus **Nyroca**.

Nyroca Fleming, Philos. Zool., II, 1822, 260.
4 species, 3 of which are congeneric.
"*Anas ferina, Marila* [,] *nyroca, fuligula.*"

Type, by tautonomy, *Anas nyroca* Güldenst. 1769, the third species.

Nyroca replaces *Aythya* (Boie, 1822) of the Check-List, the latter being preoccupied by *Æthia* (or *Æthya*) Dumont, 1816. (*Cf.* Stone, Auk, XXIV, April, 1907, p. 190.) *Aythya* of Boie has the same four species, and placed in the same order, as Fleming's *Nyroca*, with a fifth (additional) species *Anas mersa* Pall., a species of *Erismatura* Bonap. 1832.

Subgenus **Aristonetta**.

Aristonetta Baird, Bds. N. Amer., 1858, 793 (in text).

Tentatively proposed, "for the canvas-back"; hence monotypic, with *Anas vallisneria* Wils. as the type.

Subgenus **Fuligula**.

Fuligula Stephens, Gen. Zool., XII, ii, 1824, 189.
14 species, representing about 7 modern genera.

1. *cristata* = *Anas fuligula* Linn.
2. *islandica*,
3. *ferina*,
4. *vallisneria*,
5. *marila*,
6. *nyroca*,
7. *dominica*,
8. *fulva*,
9. *ferruginea*,
10. *dispar*,
11. *caryophyllacea*,
12. *bicolor*,
13. *gmelini*,
14. *novæ-zelandiæ*.

Type, by tautonomy, as designated by Gray (1840), and also by the first species rule, *Fuligula cristata* Steph. = *Anas fuligula* Linn., the species figured to illustrate the genus. (According to Mr. Stone (Auk, XXIV, April, 1907, p. 191), *Fuligula* must be replaced by *Marila* Oken, 1817.)

Genus **Clangula**.

Clangula Leach, Ross's First Voy. Disc., 1819, App. II, p. xlviii.
"Genus *Clangula*, Gesner (Garrot)."

The only species mentioned, and the only one that called for notice in this connection, is "*Clangula glacialis* (Northern Garrot)." Salvadori (Cat. Bds. Brit. Mus., XXVII, 1895, p. 376, footnote) is doubtless quite right in saying: "Although Leach mentions *Clangula glacialis* only, the type of the genus is obviously *Anas clangula* Linn. In fact Leach has *Clangula*, from Gesner's *Clangula*, French 'Garrot,' which is *A. clangula* Linn."

The type, by tautonomy, is evidently *Anas clangula* Linn.

[Genus **Glaucionetta**.

Glaucionetta Stejneger, Proc. U. S. Nat. Mus., 1885, 409.

Type, by designation, *Anas clangula* Linn. To replace *Clangula* Leach 1819, and so employed in the A. O. U. Check-List down to 1897. (See Eighth Suppl., Auk, XIV, Jan. 1897, p. 124.)]

Genus **Charitonetta**.

Charitonetta Stejneger, Orn. Expl. Kamtsch., 1885, 163.

Monotypic, with type, by designation, *Anas albeola* Linn., a species commonly treated as congeneric with *A. clangula* Linn.

Genus **Harelda**.

Harelda Stephens, Gen. Zool., XII, ii, 1824, 174.

Monotypic, with *Harelda glacialis* = *Anas hyemalis* + *glacialis* Linn., as type.

Genus **Histrionicus**.

Histrionicus Lesson, Man. d'Orn., II, 1828, 415.

Monotypic, with *Anas histrionica* Linn. as type.

Genus **Camptolaimus**.

Camptolaimus Gray, List Gen. Bds., 1841, 95.

Monotypic, with *Anas labradoria* Gmel. as type by designation. Ante-

dated by *Kamptorhynchus* Eyton (Mon. Anat., 1838, p. 57) with same type. (*Cf.* Stone, Auk, XXIV, April, 1907, p. 191.)

Genus **Polysticta**.

Polysticta Eyton, Cat. Brit. Bds., 1836, 58.

Monotypic, with *P. stelleri* = *Anas stelleri* Pall. as type. (Has slight priority over *Polysticta* Smith, 1836. *Cf.* Richmond, Proc. Biol. Soc. Wash., XVI, 1903, 128.)

Genus **Arctonetta**.

Arctonetta Gray, Proc. Zool. Soc. London, 1855 (Feb. 1856), 212.

Monotypic, with *Fuligula fisheri* Brandt as type. To replace *Lampronetta* Brandt, 1847, because "*Lampronetta* is so near *Lampronessa* of Wagler," 1832.

Genus **Somateria**.

Somateria Leach, Ross's First Voy. Disc., 1819, App. II, p. xlviii.
2 congeneric species.

1. *Somateria spectabilis*, type of subgenus *Erionetta* Coues, 1884.
2. "*Somateria* (Cuthbert's Eider), commonly named the Eider Duck" = Eider or Cuthbert Duck, Pennant (1776) and Latham (1785) = *Anas cuthberti* Pallas (part) = *Somateria St. cuthberti* Eyton = *Somateria mollissima borealis* Brehm.

Type, as designated by Gray (1840) and by elimination, *Anas mollissima* Linn.; type by the first species rule, *Anas spectabilis* Linn.[1]

Subgenus **Erionetta**.

Erionetta Coues, Key N. Amer. Bds., ed. 2, 1884, 709.

Monotypic, with *Anas spectabilis* Linn. as type by designation.

Genus **Oidemia**.

Oidemia Fleming, Philos. Zool., II, 1822, 260.
2 noncongeneric species.

1. *nigra*.
2. *fusca*, type of subgenus *Melanitta* Boie, 1822.

Type, as designated by Gray (1840) and by elimination, *Anas nigra* Linn., the first species.

Subgenus **Melanitta**.

Melanitta Boie, Isis, 1822, 564.
3 noncongeneric species.

[1] Since this paper was sent to the printer Mr. Stone has called my attention to the use of the name *Somateria* by Dr. Leach in possibly an earlier connection (Thompson's Annals of Philosophy, Vol. XIII, Jan. 1819, p. 60), where we have the following: "23. *Somateria Mollissima* (Cuthbert's Eider). Baffin's Bay, Spitzbergen." As here used, *Somateria* is monotypic.

1. *nigra*, type of *Oidemia* Fleming, 1822.
2. *fusca*.
3. *perspicillata*, type of *Pelionetta* Kaup, 1829.

Type, as designated by Gray (1840) and by elimination, *Anas fusca* Linn., the second species.

By the first species rule *Melanitta* is a synonym of *Oidemia* Flem. 1822, both having the same first species. For this reason Mr. Stone has proposed *Phœonetta*, with same type, to replace *Melanitta*. (*Cf.* Auk, XXIV, April, 1907, p. 198.)

Subgenus **Pelionetta**.

Pelionetta Kaup, Skizz. Entw.-Gesch. Eur. Thierw., 1829, 107, 196.

Monotypic, with *Anas perspicillata* Linn. as type.

Genus **Erismatura**.

Erismatura Bonaparte, Saggio Dist. Meth. Anim. Vertebr. a sangue fredo, 1832, 85.

Monotypic, to replace *Oxyura* Bonap. 1827 (not *Oxyurus* Swains.) with the same type, = *Fuligula rubida* Bonap. = *Anas rubida* Wilson = *Anas jamaicensis* Gmel.

Genus **Nomonyx**.

Nomonyx Ridgway, Proc. U. S. Nat. Mus., 1880, 15.

Monotypic, with *Anas dominica* Linn. as type.

Genus **Chen**.

Chen Boie, Isis, 1822, 563.

Monotypic, with *Anser hyperboreus* Pallas as type.

Subgenus **Exanthemops**.

Exanthemops Elliot, Ill. Bds. N. Am., II, pt. ix, 1868, pl. xliv.

Monotypic, with *Anser rossii* Cass. (ex Baird MSS.) as type.

Genus **Anser**.

Anser Brisson, Orn. VI, 1760, 261.
16 species (nominally); includes only Geese and Swans.

Type, by tautonomy, *Anser domesticus* Gesner = *Anas anser* Linn.

Genus **Branta**.

Branta Scopoli, Ann. I, Hist. Nat., 1769, 67.
4 noncongeneric species.

1. "*Branta bernicla* Linn."
2. "*Branta moschata* Linn.," type of *Cairina* Fleming, 1822.
3. "*Branta torrida* sp. nov.," a hybrid, probably of Muscovy and Mallard.
4. "*Branta albifrons* sp. nov.," a species of *Anser* Briss. 1760.

Type by elimination, *Anas bernicla* Linn., the first species.

Genus **Philacte**.

Philacte Bannister, Proc. Acad. Nat. Sci. Phila., 1870, 131.

Monotypic, for *Anas canagica* Sevast.

Genus **Dendrocygna**.

Dendrocygna Swainson, Class. Bds., II, 1837, 365.
2 congeneric species, *arcuata* and *arborea*.

Type, as designated by Gray (1840) and by general consent, *Anas arcuata* Horsf. (ex Cuv. MSS.), the first species.

Genus **Olor**.

Olor Wagler, Isis, 1832, 1234.
3 congeneric species. (1) *musicus*, (2) *bewickii*, (3) *buccinator*.

Type, by inference, as designated by Gray (1840), and general usage, *Olor musicus* = *Cygnus musicus* Bechst. = *Anas cygnus* Linn. (part), the first species.

Cygnus was here restricted by Wagler to *Cygnus gibbus* Bechst. = *Anas olor* Gmel., the two genera, *Olor* and *Cygnus*, being separated on the basis of important anatomical differences. Under the rule of tautonomy, the names of the two groups should have been transposed, *Cygnus* taking the place of *Olor*, and *vice versa*, but the enforcement of the rule is now obviously not permissible.

Family PHŒNICOPTERIDÆ.

Genus **Phœnicopterus**.

Phœnicopterus Linnæus, Syst. Nat., ed. 10, I, 1758, 139.

Monotypic, with *Phœnicopterus ruber* Linn. as type.

Family PLATALEIDÆ.

Genus **Ajaia**.

Ajaia Reichenbach, Syst. Av., 1852, p. xvi.

Monotypic, with "*Ardea rosea* Barr." = *Platalea ajaja* Linn. as type; also tautonymic.

Family IBIDIDÆ.

Genus **Guara**.

Guara Reichenbach, Syst. Av., 1852, p. xiv.

Monotypic, with *Tantalus ruber* Linn. 1766 = *Scolopax ruber* 1758, as type.

Genus **Plegadis**.

Plegadis Kaup, Skizz. Entw.-Gesch. Eur. Thierw., 1829, 82.

Monotypic, with *Tantalus falcinellus* Linn. = *Tringa autumnalis* Hasselq. as type.

Family CICONIIDÆ.

Genus **Tantalus**.

Tantalus Linnæus, Syst. Nat., ed. 10, 1758, 140.

Monotypic, with *Tantalus loculator* Linn. as type.

Genus **Mycteria**.

Mycteria Linnæus, Syst. Nat., ed. 10, 1758, 140.

Monotypic, with *Mycteria americana* Linn., as type.

Family ARDEIDÆ.

Genus **Botaurus**.

Botaurus Stephens, Gen. Zool., XI, ii, 1819, 592.

7 species, representing 5 modern genera.

1. *stellaris*.
2. *lentiginosus*, congeneric with No. 1.
3. *undulatus* = *pumila* Bodd., type of *Zebrilus* Bonap. 1855.
4. *brasiliensis*, type of *Tigrisoma* Swains. 1827.
5. *flavus*, same as No. 4.
6. *senegalensis* = *ralloides* Scop., type of *Ardeola* Boie, 1822.
7. *virescens*, a species of *Butorides* Blyth, 1849.

Type, as designated by Gray (1840) and by general consent, *Ardea stellaris* Linn., the first species.

The genus *Botaurus* has been wrongly ascribed to Brisson, who used the term merely as a species name for the twenty-fourth species of his genus *Ardea*. It has also been ascribed to Hermann, 1783, but Hermann used it merely in the text, *passim*, in a Latin work, and in a way that renders very doubtful the propriety of taking the name as a generic term from this source.

Genus **Ardetta**.

Ardetta GRAY, List Gen. Bds., 1842, App., 13.

Type, by designation, *Ardea minuta* Linn.; also monotypic. According to Mr. Stone (Auk, XXIV, April, 1907, p. 192) *Ardetta* is to be replaced by *Ixobrychus* Billberg, 1828.

Genus **Ardea**.

Ardea LINNÆUS, Syst. Nat., ed. 10, 1758, 141.

19 species, representing 14 modern genera, 2 orders, and 3 families.

* *Cristatæ*: rostro vix capite longiore.

1. *pavonina*, type of *Balearica* Briss. 1760.
2. *virgo*, type of *Anthropoides* Vieill. 1816.

** *Grues*: capite calvo.

3. *canadensis*, congeneric with No. 4.
4. *grus*, type of *Grus* Pall. 1767.
5. *americanus*, type of subgenus *Limnogeranus* Sharpe, 1893.
6. *antigone*, type of *Antigone* Reich. 1852.

*** *Ciconiæ*.

7. *ciconia*, type of *Ciconia* Briss. 1760.
8. *nigra*, congeneric with No. 7.

**** *Ardeæ*.

9. *nycticorax*, type of *Nycticorax* Steph. 1819.
10. *cinerea*.
11. *herodias*, congeneric with No. 10.
12. *violacea*, type of *Nyctanassa* Stejn. 1887.
13. *cærulea*, type of *Florida* Baird, 1858.
14. *striata*, congeneric with No. 15.
15. *virescens*, congeneric with type of *Butorides* Blyth. 1849.
16. *stellaris*, type of *Botaurus* Steph. 1819.
17. *alba*, a species of *Herodias* Boie, 1822.
18. *ibis* = *bubulcus* Audouin, type of *Bubulcus* Bonap. 1854.
19. *æquinoctialis*, doubtfully identifiable with *Ardea rufa* Bodd., the type of *Dichromanassa* Ridgw. 1878.

Type, as designated by Gray (1840) and by elimination, *Ardea cinerea* Linn., the tenth species, and the only species which has not been taken as the type of some other genus or is not congeneric with species which have been taken as the types of other genera. By general consent, *A. cinerea* has been the type of *Ardea* for nearly a century.

Genus **Herodias**.

Herodias BOIE, Isis, 1822, 559.

2 noncongeneric species.

1. *egretta*.
2. *garzetta*, type of *Egretta* Forster, 1817.

Type, as designated by Gray (1840) and by elimination, *Ardea egretta* Gmel., the first species.

Genus **Egretta**.

Egretta FORSTER, Syst. Cat. Brit. Bds., 1817, 59.

Monotypic, with *Ardea garzetta* Linn. as type.

Genus **Dichromanassa**.

Dichromanassa RIDGWAY, Bull. U. S. Geol. and Geogr. Survey Terr. (Hayden) IV, 1878, 246.

Monotypic, with *Ardea rufa* Linn. as type.

Genus **Hydranassa**.

Hydranassa BAIRD, Bds. N. Amer., 1858, 660 (in text).

Tentatively proposed for *Ardea ludoviciana* Wilson = *Hydranassa tricolor ruficollis* (Gosse).

Genus **Florida**.

Florida BAIRD, Bds. N. Amer., 1858, 671.

Monotypic, with *Ardea cærulea* Linn. as type.

Genus **Butorides**.

Butorides BLYTH, Cat. Bds. As. Soc., 1849, 281.

Monotypic, with *Ardea javanica* Horsf. as type.

Genus **Nycticorax**.

Nycticorax STEPHENS, Gen. Zool., XI, ii, 1819, 608.
4 species (2 of them nominal), representing 2 modern genera.

Type, by tautonomy, *Nycticorax europeus* Steph. = *Ardea nycticorax* Linn., which is also the first species, and is figured to illustrate the genus.

Genus **Nyctanassa**.

Nyctanassa STEJNEGER, Proc. U. S. Nat. Mus., 1887, 295.

Monotypic, with *Ardea violacea* Linn. as type.

Family GRUIDÆ.

Genus **Grus**.

Grus PALLAS, Misc. Zool., 1766, 66; Spicel. Zool., fasc. iv, 1767.

Grus was proposed by Pallas for a miscellaneous group of birds, the diagnosis of which ("....*Capite* gaudent plumosiore, quam Ardeæ atque sæpe vario ornatu insigni; ....") apparently excludes the Cranes with bare heads referred by modern writers to the genus *Grus*. The only species mentioned by Pallas under *Grus* is *Psophia crepitans* Linn.

By general consent, *Grus* has been accredited to Pallas by subsequent authors, with *Ardea grus* Linn. (as designated by Gray, 1840) as type. Duméril in 1806 (Zool. Analyt., p. 62) first restricted the genus to the group of Cranes with bare heads now alone included in *Grus*.

Family ARAMIDÆ.

Genus **Aramus**.

Aramus Vieillot, Analyse, 1816, 58.

Monotypic, with "Courliri, Buff." = *Ardea scolopacea* Linn. as type.

Family RALLIDÆ.

Genus **Rallus**.

Rallus Linnæus, Syst. Nat., ed. 10, I, 1758, 153.

5 species, representing 5 genera, 3 families, and 3 orders.

1. *crex*, the type of *Crex* Bechst. 1802.
2. *aquaticus*.
3. *lariformis* = *Sterna nigra* Linn., *l. c.* p. 137, type of *Hydrochelidon* Boie, 1822.
4. *benghalensis* = *Scolopax capensis* Linn. 1766, type of *Rostratulus* Vieill. 1816.
5. *carolinus*, a species of *Porzana* Vieill. 1816.

Type, by elimination, and as designated by Gray (1840), *Rallus aquaticus* Linn., the second species. This was the only species included in *Rallus* by Bechstein in 1802 (Orn. Taschenb. Deutchl., 1802, p. 335).

Genus **Porzana**.

Porzana Vieillot, Analyse, 1816, 61.

Monotypic, with the "Marouette, Buff." = *Rallus porzana* Linn., as type; hence also tautonymic.

Genus **Coturnicops**.

Coturnicops Bonaparte, Compt. Rend., XLIII, 1856, 569.

Monotypic, with *Fulica noveboracensis* Gmel. as type.

Genus **Creciscus**.

Creciscus Cabanis, Journ. f. Orn., 1856, 428.

Monotypic, with *Rallus jamaicensis* Gmel. as type.

Genus **Crex**.

Crex Bechstein, Orn. Taschenb. Deutschl., 1802, 336.

Type, by tautonomy, *Rallus crex* Linn.; also monotypic.

Genus **Ionornis.**

Ionornis Reichenbach, Syst. Av., 1850, p. xxi.

Monotypic, with *Fulica martinica* Linn. as type.

Genus **Gallinula.**

Gallinula Brisson, Orn. VI, 1760, 2.

Type, by tautonomy, [*Gallinula*] *gallinula* Briss. = *Fulica chloropus* Linn., the first species.

Genus **Fulica.**

Fulica Linnæus, Syst. Nat., ed. 10, I, 1758, 152.

4 species, representing 4 modern genera and 2 families.

1. *atra.*
2. *chloropus*, type of *Gallinula* Briss., 1760.
3. *porphyrio*, type of *Porphyrio* Briss., 1760.
4. *spinosa* = *Parra variabilis* Linn. 1766 (part), type of subgenus *Asarcia* Sharpe, 1896.

Type, as designated by Gray (1840) and by elimination, *Fulica atra* Linn., the first species.

Family PHALAROPODIDÆ.

Genus **Crymophilus.**

Crymophilus Vieillot, Analyse, 1816, 62.

Monotypic, with "Phalarope à festons dentelés, Buff." = *Tringa fulicaria* Linn. as type. *Crymophilus* is hence a synonym of *Phalaropus* Brisson, which has, by tautonomy, the same type. (*Cf.* Stone, Auk, XXIV, April, 1907, 196.)

Genus **Phalaropus.**

Phalaropus Brisson, Orn. VI, 1760, 12.

Type, by tautonomy, [*Phalaropus*] *phalaropus* Briss. = *Tringa fulicaria* Linn., the first species. *Phalaropus* of the Check-List will be replaced by *Lobipes* Cuvier, 1817, with the same type.

Genus **Steganopus.**

Steganopus Vieillot, Nouv. Dict. d'Hist. Nat., XXXII, 1819, 136.

Monotypic, with *S. tricolor* Vieill. sp. nov., as type.[1]

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[1] Through the above changes in generic names, the Phalaropes will stand as follows (the Check-List equivalents in parentheses):

222. *Phalaropus fulicarius* (= *Crymophilus fulicarius*).
223. *Lobipes lobatus* (= *Phalaropus lobatus*).
224. *Steganopus tricolor* (= *Steganopus tricolor*).

Family RECURVIROSTRIDÆ.

Genus **Recurvirostra.**

Recurvirostra Linnæus, Syst. Nat., ed. 10, I, 1758, 151.

Monotypic, with *R. avocetta* Linn. as type.

Genus **Himantopus.**

Himantopus Brisson, Orn. V, 1760, 33.
2 congeneric species.

Type, by tautonomy, [*Himantopus*] *himantopus* Briss. = *Charadrius himantopus* Linn.

Family SCOLOPACIDÆ.

Genus **Scolopax.**

Scolopax Linnæus, Syst. Nat., ed. 10, I, 1758, 145.
14 species, representing 6 modern genera.

1. *rubra*, type of *Guara* Reich. 1852.
2. *alba*, congeneric with No. 1.
3. *fusca*, young of No. 2.
4. *totanus*, type of *Totanus* Bechst. 1803.
5. *arquata*, type of *Numenius* Briss. 1760.
6. *phæopus*, congeneric with No. 5; type of *Phæopus* Cuv. 1817.
7. *rusticola*, type of *Rusticola* Vieill. 1816 = *Scolopax* Koch, 1816.
8. *fedoa*, congeneric with No. 10.
9. *glottis*, not positively determinable.
10. *limosa*, type of *Limosa* Briss. 1760.
11. *gallinago*, type of *Gallinago* Koch, 1816.
12. *lapponica*, congeneric with No. 10.
13. *ægocephala*, congeneric with No. 10.
14. *hæmastica*, congeneric with No. 10.

Type, by restriction, as designated by Gray (1840), and by general usage, *Scolopax rusticola* Linn., the seventh species.

Scolopax Linn. was restricted by Koch (Syst. Baier. Zool., I, 1816, p. 310) to *Scolopax rusticola* Linn. only.

Genus **Philohela.**

Philohela Gray, List Gen. Bds., 1841, 90.

Monotypic, with *Scolopax minor* Gmel., as type; also type by designation.

Genus **Gallinago.**

Gallinago Koch, Baier. Zool., I, 1816, 312.
3 congeneric species, *major, media, minor.*

Type, by tautonomy, *Gallinago media* = *Scolopax gallinago* Linn., the second species.

Genus **Macrorhamphus.**

Macrorhamphus Forster, Syst. Cat. Brit. Bds., 1817, 57.

Monotypic, with *Scolopax griseus* Gmel. as type.

Genus **Micropalama.**

Micropalama Baird, N. Am. Bds., 1858, 726.

Monotypic, with *Tringa himantopus* Bonap. as type.

Genus **Tringa.**

Tringa Linnæus, Syst. Nat., ed. 10, I, 1758, 148.
13 species, representing 11 modern genera, and 3 families.

1. *pugnax*, type of *Pavoncella* Forster, 1817.
2. *vanellus*, type of *Vanellus* Briss. 1760.
3. *gambetta*, not satisfactorily identifiable.
4. *interpres*, type of *Arenaria* Briss. 1760.
5. *lobata*, type of *Lobipes* Cuv. 1817.
6. *fulicaria*, type of *Phalaropus* Briss. 1760.
7. *alpina*, type of *Pelidna* Cuv. 1817.
8. *ochropus*, type of *Helodromas* Kaup, 1829.
9. *hypoleucos*, type of *Actitis* Ill. 1811.
10. *canutus*, type of *Calidris* Cuv. 1817 (nec Illiger, 1811) and of *Canutus* Brehm, 1831.
11. *glareola*, type of *Rhyacophilus* Kaup, 1829.
12. *littorea*, same as No. 1.
13. *squatarola*, type of *Squatarola* Cuv. 1817.

Type, as designated by Gray (1840) and by elimination, *Tringa canutus* Linn., the tenth species. By all authors except Cuvier and Brehm, *canutus* has been retained in the restricted genus *Tringa*, and regarded as its type.

Genus **Arquatella.**

Arquatella Baird, Bds. N. Am., 1858, 714, 717.

Monotypic, with *Tringa maritima* Brünn., as type.

Genus **Actodromas.**

Actodromas Kaup, Skizz. Entw.-Gesch. Eur. Thierw., 1829, 55.

Monotypic, with *Tringa minuta* Leisler as type.

Genus **Pelidna.**

Pelidna Cuvier, Règne Anim., I, 1817, 490.
2 noncongeneric species.

1. *cinclus*.
2. *subarquata*, type of *Anucylocheilus* Kaup, 1829.

Type, by elimination, *Totanus cinclus* Linn. 1766 = *T. alpina* Linn., 1758, the first species.

Genus **Erolia.**

Erolia Vieillot, Analyse, 1816, 55, 69; Nouv. Dict. d'Hist. Nat., nouv. éd., X, 1817, 409; Gal. des Ois., II, 1825, 88.

Monotypic, with *Erolia variegata* sp. nov. = *Tringa subarquata* Temm. = *Tringa ferruginea* Brünn. as type.

In the 10th Supplement to the Check-List (Auk, XX, 1903, p. 337), *Erolia* was substituted for *Ancylocheilus* Kaup, 1829, on the ground that *Erolia variegata* Vieill. = *Tringa ferruginea* Brünn., 1764, "although described and figured by Vieillot as a three-toed species." The genus *Erolia* has been rejected by Gray and nearly all other authors, in some cases on the ground that it was based on an *avis fic.*, or on an artifact.

Genus **Eurynorhynchus.**

Eurynorhynchus Nilsson, Orn. Suec., II, 1824, 29.

Monotypic, with *Eurynorhynchus griseus* Nilsson = *Platalea pygmæa* Linn. as type.

Genus **Ereunetes.**

Ereunetes Illiger, Prodr., 1811, 262.

Monotypic, with *E. petrificatus* Ill. = *Tringa pusilla* Linn. 1766, as type.

Genus **Calidris.**

Calidris Illiger, Prodr., 1811, 449.

Monotypic, with "*Charadrius calidris* Linn." 1766, p. 255 = *Tringa arenaria* Linn. 1766, p. 251, as type; hence also tautonymic.

In the Check-List *Calidris* is taken from Cuvier, 1799, where, however, it is a *nomen nudum*; as first defined by Cuvier in 1817 (Règn. Anim., I, 1817, p. 489) it is based on *Tringa canutus* Linn., but at this date the name was preoccupied by *Calidris* Ill. 1811.

Genus **Limosa.**

Limosa Brisson, Orn., V, 1760, 261.

8 species (7 valid), representing 3 modern genera; includes 4 of the 5 species of the modern genus *Limosa*.

Type, by tautonomy, [*Limosa*] *limosa* Briss. = *Scolopax limosa* Linn.

Genus **Totanus.**

Totanus Bechstein, Orn. Tashenb. Deutschl., 1803, 282.

11 species, including 4 modern genera.

Type, by tautonomy, *Scolopax totanus* Linn.

Genus **Glottis.**

Glottis Koch, Baier. Zool., I, 1816, 304.

2 noncongeneric species.

1. *natans* = *Totanus glottis* Bechst. = *Scolopax nebularius* Gunn. 1767 (= nec *Scolopax glottis* Linn. 1758).
2. *stagnalis*, a species of *Totanus* Bechst. 1803.

Type, by tautonomy, and also by elimination, *Scolopax nebularius* Gunn., the first species.

Genus **Helodromas.**

Helodromas Kaup, Skizz. Entw.-Gesch. Eur. Thierw., 1829, 144, 195.

Monotypic, with *Tringa ochropus* Linn. as type.

Genus **Symphemia.**

Symphemia Rafinesque, Journ. de Phys., LXXXVIII, 1819, 418.

"Type, *T. semi-palmata* que je nomme *S. atlantica*" = *Tringa semipalmata* Wils., type of *Ereunetes* Ill. 1811 (*teste* Richmond).

Symphemia is thus a synonym of *Ereunetes*. For *Symphemia* of the A. O. U. Check-List *Catoptrophorus* Bonap. is available. (*Cf.* Richmond, Proc. Biol. Soc. Wash., XVIII, 1905, 75.)

[Genus **Catoptrophorus.**

Catoptrophorus Bonaparte, Ann. Lyc. Nat. Hist. New York, II, 1827, 323.

Monotypic, with *Totanus semipalmatus* Temm. = *Scolopax semipalmata* Gmel. as type.]

Genus **Heteractitis.**

Heteractitis Stejneger, Auk, I, July, 1884, 236.

Monotypic, with *Scolopax incanus* Gmel. as type; to replace *Heteroscelus* Baird, 1858, p. 734, preoccupied, with the same type.

Genus **Pavoncella.**

Pavoncella Leach, Syst. Cat. Mamm. and Bds. Br. Mus., 1816, 29.

Monotypic, with *Tringa pugnax* Linn., as type. There can be no doubt whatever that Leach's "*Pavoncella pugnax*, Fighting Ruff," is the same bird as Cuvier's (Règne Anim., I, 1817, p. 490) "les Combattans, *machetes*" although in the latter case the name is associated with "*Tringa pugnax* Linn.," and in the former case there is lack of this additional identification. But the specific name *pugnax* has never been associated with any other species of Sandpiper. If all of Leach's genera in this work (*l. c.*)

are treated as *nomina nuda,* then *Machetes* Cuvier, 1817, with same type, will replace *Pavoncella.* (*Cf.* Stone, Auk, XXIV, April, 1907, 195.)

Genus **Bartramia.**

Bartramia Lesson, Traité d'Orn., 1831, 553.

Monotypic, with *B. laticauda* Less. = *Tringa bartramia* Wils. = *Tringa longicauda* Bechst. as type; also tautonymic.

Genus **Tryngites.**

Tryngites Cabanis, Journ. f. Orn., 1856, 418.

Monotypic, with *Tringa rufescens* Vieill. = *T. subruficollis* Vieill. as type.

Genus **Actitis.**

Actitis Illiger, Prodr., 1811, 262.
4 species, representing 4 modern genera.

1. *Scolopax limosa* Linn., type of *Limosa* Briss. 1760.
2. " *totanus* Linn., type of *Totanus* Bechst. 1803.
3. *Tringa pugnax* Linn., type of *Pavoncella* Leach, 1816.
4. " *hypoleucos* Linn.

Type, by elimination, *Tringa hypoleucos* Linn., the last species. (*Actitis* Boie, 1822 (Isis von Oken, p. 560), contained only the single species *Tringa hypoleucos* Linn.)

By first species rule the type would be *Scolopax limosa* Linn., rendering *Actitis* a synonym of *Limosa* Brisson, 1760, although ten of the twelve species contained in the two genera are different, and are now currently referred to five different genera.

Genus **Numenius.**

Numenius Brisson, Orn., V, 1760, 311.

Type, by tautonomy, [*Numenius*] *numenius* Briss. = *Scolopax arquata* Linn.

Family CHARADRIIDÆ.

Genus **Vanellus.**

Vanellus Brisson, Orn. V, 1760, 94.

Type, by tautonomy, [*Vanellus*] *vanellus* Briss. = *Tringa vanellus* Linn.

Genus **Eudromias.**

Eudromias Brehm, Vog. Deutschl., 1831, 544.
3 nominal species = *Charadrius morinellus* Linn.

Monotypic, with *Charadrius morinellus* Linn., as type.

Genus **Squatarola**.

Squatarola Cuvier, Règn. Anim., I, 1817, 467.

Type, by tautonomy, *Tringa squatarola* Linn.; also monotypic.

Genus **Charadrius**.

Charadrius Linnæus, Syst. Nat., ed. 10, I, 1758, 150.
11 species, representing 8 modern genera and 4 families.

1. *cristatus* = *vanellus* Linn. 1766, type of *Vanellus* Briss. 1760.
2. *hiaticula*, type of *Ægialitis* Boie, 1822.
3. *alexandrinus*, congeneric with No. 2.
4. *vociferus*, type of *Oxyechus* Reich. 1853.
5. *ægyptius*, type of *Pluvianus* Vieill. 1816.
6. *morinellus*, type of *Eudromias* Brehm, 1831.
7. *apricarius*.
8. *pluvialis*, same as No. 7.
9. *œdicnemus*, type of *Œdicnemus* Temm. 1815.
10. *himantopus*, type of *Himantopus* Briss. 1760.
11. *spinosus*, type of *Hoplopterus* Bonap. 1831.

Type, by elimination, as designated by Gray (1840), and by general usage, *C. apricarius* Linn. (= *pluvialis* Linn.), the seventh species.

Genus **Oxyechus**.

Oxyechus Reichenbach, Syst. Av., 1852, p. xviii.

Monotypic, with *Charadrius vociferus* Linn. as type.

Genus **Ægialitis**.

Ægialitis Boie, Isis, 1822, 558.
3 congeneric species.

1. *hiaticula*.
2. *cantianus*, congeneric with No. 1.
3. *minor*, congeneric with No. 1.

Type, as designated by Gray (1855), and by general consent, *Charadrius hiaticula* Linn.

Genus **Ochthodromus**.

Ochthodromus Reichenbach, Syst. Av., 1852, p. xviii.

Monotypic, with *Charadrius wilsonius* Ord as type.

Genus **Podasocys**.

Podasocys Coues, Proc. Acad. Nat. Sci. Phila., 1866, 96.

Monotypic, with *Charadrius montanus* Towns. as type.

Family APHRIZIDÆ.

Genus **Aphriza**.

Aphriza Audubon, Orn. Biog., V, 1839, 249, 251 (in text).

Monotypic, with *A. townsendi* Aud. = *Tringa virgata* Gmel. as type.

Genus **Arenaria**.

Arenaria Brisson, Orn., V, 1760, 132.

Monotypic, with [*Arenaria*] *arenaria* Briss. = *Tringa interpres* Linn. as type; also tautonymic.

Family HÆMATOPODIDÆ.

Genus **Hæmatopus**.

Hæmatopus Linnæus, Syst. Nat., ed. 10, I, 1758, 152.

Monotypic, with *H. ostralegus* Linn. as type.

Family JACANIDÆ.

Genus **Jacana**.

Jacana Brisson, Orn., V, 1760, 121.

Type, by tautonomy, [*Jacana*] *jacana* + *Jacana armata fusca* Briss. = *Parra jacana* Linn. (Not *Fulica spinosa* Linn., as formerly given in the Check-List.)

Subgenus **Asarcia**.

Asarcia Sharpe, Cat. Bds. Brit. Mus., XXIV, 1896, 86.

Monotypic, with *Parra variabilis* Linn. 1766 = *Fulica spinosa* Linn. 1758, as type.

Family TETRAONIDÆ.

Genus **Colinus**.

Colinus Goldfuss, Handb. Zool., II, 1820, 220.

Monotypic, with "*P*[*erdix*] *mexicana*. Caille de la Louisiana. Pl. Enl. 149, Frisch, t. 113" = *Tetrao virginianus* Linn. as type.

Genus **Oreortyx**.

Oreortyx Baird, Bds. N. Am., 1858, 642.

Monotypic, with *Ortyx pictus* Douglas as type.

Genus **Callipepla**.

Callipepla Wagler, Isis, 1832, 277.

Monotypic, with *C. strenua* Wagler = *Ortyx squamatus* Vig. as type.

Genus **Lophortyx.**

Lophortyx Bonaparte, Geogr. and Comp. List, 1838, 42.
2 congeneric species, *Tetrao californicus* Shaw, and *Ortyx douglasi* Vigors.

Type, as designated by Gray (1840) and by general consent, *Tetrao californicus* Shaw, the first species.

Genus **Cyrtonyx.**

Cyrtonyx Gould, Mon. Odontoph., pll. vii, and viii, 1844, and Introd., 1850, 14.
2 congeneric species, *Ortyx massena* Less. = *O. montezumæ* Vig., and *O. ocellatus* Gould.

Type, as designated by Gray (1855) and by general consent, *O. montezumæ* Vig., the first species.

Genus **Dendragopus.**

Dendragopus Elliot, Proc. Acad. Nat. Sci. Phila., 1864, 23.

Monotypic, with *Tetrao obscurus* Say as type.

Genus **Canachites.**

Canachites Stejneger, Proc. U. S. Nat. Mus., 1885, 410.

To replace *Canace* Reich. 1852, preoccupied, with type by designation, *Tetrao canadensis* Linn.

Genus **Bonasa.**

Bonasa Stephens, Gen. Zool., XI, ii, 1819, 298.
2 noncongeneric species.
1. *Tetrao cupido* Linn., type of *Tympanuchus* Gloger, 1842.
2. " *umbellus* Linn.

Type, as designated by Gray (1840) and by elimination, *Tetrao umbellus* Linn.; type by first species rule *T. cupido* Linn., rendering *Tympanuchus* a synonym and a new name necessary for the group in the A. O. U. Check-List now universally recognized as *Bonasa*. (Mr. Stone has proposed, Auk, XXIV, April, 1907, 198, to replace it with *Hylobrontes* nom. nov.)

Genus **Lagopus.**

Lagopus Brisson, Orn., I, 1760, 181.

Type, by tautonomy, [*Lagopus*] *lagopus* Briss. = *Tetrao lagopus* Linn., the twelfth and last species of the genus.

Genus **Tympanuchus.**

Tympanuchus Gloger, Gemein. Hand. und Hilfsbuch Naturg., 1842, 396.

Monotypic, with *Tympanuchus cupido* Gloger ("Cupidohuhn") = *Tetrao cupido* Linn. as type.

Genus **Pediœcetes.**

Pediœcetes Baird, Bds. N. Am., 1858, 625.

Monotypic, with *Tetrao phasianellus* Linn. as type.

Genus **Centrocercus.**

Centrocercus Swainson, Faun. Bor.-Am., II, 1831 (1832), xxviii, xxxiv, 358, 361, 496.

2 noncongeneric species.

1. *Tetrao urophasianus* Bonap.
2. *Tetrao phasianellus* Linn.

Type, as designated by the founder, *Tetrao urophasianus* Linn., the first species.

[Genus **Tetrao.**

Tetrao Linnæus, Syst. Nat., ed. 10, I, 1758, 159.

13 species, representing 12 modern genera.

1. *urogallus*, type of *Urogallus* Scopoli, 1777, and of Fleming, 1822.
2. *tetrix*, type of *Lyrurus* Swains. 1832.
3. *canadensis*, type of *Canace* Reich. 1852.
4. *lagopus*, type of *Lagopus* Briss. 1760.
5. *phasianellus*, type of *Pediœcetes* Bd. 1858.
6. *cupido*, type of *Tympanuchus* Glog. 1842.
7. *bonasia*, type of *Tetrastes* Keys. & Blas. 1840.
8. *rufus*, congeneric with *Caccabis* Kaup, 1829.
9. *perdix*, type of *Perdix* Briss. 1760.
10. *virginianus*, type of *Colinus* Goldfuss, 1820.
11. *marilandicus*, same as No. 10.
12. *orientalis*, type of *Pterocles* Temm. 1815.
13. *coturnix*, type of *Coturnix* Bonn. 1791.

Type, by tautonomy, *Tetrao tetrix* Linn., *tetrix* being the Greek equivalent of the Latin *tetrao*.]

Family PHASIANIDÆ.

Genus **Meleagris.**

Meleagris Linnæus, Syst. Nat., ed. 10, I, 1758, 156.

3 noncongeneric species.

1. *gallopavo*.
2. *cristata*, a species of *Penelope* Merrem, 1786.
3. *satyra*, type of *Tragopan* Cuvier, 1829.

Type, as designated by Gray (1840) and by elimination, *M. gallopavo* Linn., the first species. (By tautonomy *Gallopavo* Brisson, 1760, is a synonym of *Meleagris*; its two species are also among the original constituents of *Meleagris*.)

Family CRACIDÆ.

Genus **Ortalis**.

"*Ortalis* Merrem, Av. Rar. Icon. et Descrip., II, 1786, 40."

Not seen. In the German edition of the same date, 'Beyträge zur besonderen Geschichte der Vögel,' II, 1786, *Penelope* only is used.

Type, as designated by Gray (1840) and by general consent, *Phasianus motmot* Linn.

Family COLUMBIDÆ.

Genus **Columba**.

Columba Linnæus, Syst. Nat., ed. 10, I, 1758, 162.

22 species, representing 11 modern genera, with 8 species apparently unidentifiable.

1. *œnas, œnas β domestica,* composite; not *œnas* Linn. 1761 = *C. livia* Bonnat. 1790.
2. *gutturosa,* not identifiable.
3. *cucullata,* not identifiable.
4. *turbita,* not identifiable.
5. *tremula,* not identifiable = *laticauda* Linn. 1766.
6. *tabellaria,* not identifiable.
7. *montana,* a species of *Geotrygon* Gosse, 1847.
8. *asiatica,* not identifiable.
9. *guinea,* congeneric with No. 1.
10. *hispanica,* not identifiable.
11. *palumbus,* congeneric with No. 1; also type of *Palumbus* Kaup, 1829.
12. *cyanocephala,* type of *Starnœnas* Bonap. 1838.
13. *leucocephala,* congeneric with No. 1; also type of *Patagiœnas* Reich. 1852.
14. *leucoptera,* type of *Melopelia* Bonap. 1854.
15. *nicobarica,* type of *Calœnas* Gray, 1840.
16. *macroura,* composite, containing types of both *Ectopistes* Swains. 1827, and *Zenaidura* Bonap. 1854.
17. *sinica* = *striata* Linn. 1766, type of *Geopelia* Swains. 1837.
18. *indica,* type of *Chalcophaps* Gould, 1843.
19. *hispida,* not identifiable.
20. *turtur,* type of *Turtur* Selby, 1835.
21. *risoria,* type of *Streptopelia* Bonap. 1854.
22. *passerina,* type of *Columbigallina* Boie, 1826 (not of Oken, 1817) and of *Chamœpelia* Swains. 1827.

Type, by elimination, as designated by Gray (1855), and by general consent, *Columba livia* Bonnat. 1790 = *C. œnas* L. in part (= *C. œnas β domestica* L.).

Genus **Ectopistes**.

Ectopistes SWAINSON, Zool. Journ., III, Aug.-Nov., 1827, 362; Class. Bds., II, 1837, 348.

2 species, as follows: "Types, *Col. speciosa* ? Temm. 2. *Col. migratoria* Linn." Later (1837) the author restricted the genus by eliminating *Col. speciosa*, and retaining only "*E. migratoria*, Wilson, pl. 44, f. 1."

Hence: Type, as designated by Gray (1840), and by restriction and subsequent (1837) designation by the original author, No. 2, *Columba migratoria* Linn.

By the first species rule, *Ectopistes* would be a synonym of *Columba* Linn., *speciosa* being a species of the restricted genus *Columba*, and a new name would be required for the group universally recognized for more than half a century as *Ectopistes*. Although a ? follows the name *speciosa*, the diagnosis, "tail rounded or cuneated," implies that a species of the *speciosa* type was intended to be included in the genus when it was originally proposed. (*Cf.* Salvadori, Cat. Bds. Brit. Mus., XXI, p. 369, footnote.)

Genus **Zenaidura**.

Zenaidura BONAPARTE, Consp. Av., II, Dec. 1854, 84.

Monotypic (2 spp. but the second is a synonym of the other), with *Columba carolinensis* Linn. as type.

Genus **Zenaida**.

Zenaidura BONAPARTE, Geogr. and Comp. List, 1838, 41.

2 noncongeneric species.

1. *Zenaida amabalis* Bonap.= *Columba zenaida* Bonap.
2. *Zenaida montana* (Linn.), a species of *Geotrygon* Gosse, 1847.

Type, by tautonomy, and also by elimination, *Columba zenaida* Bonap., the first species.

Genus **Leptotila**.

Leptotila SWAINSON, Class. Bds., II, 1837, 349.

Monotypic, with *P*[*eristera*] *rufaxilla* Selby as type.

Genus **Melopelia**.

Melopelia BONAPARTE, Consp. Av., Dec. 1854, 81.

2 congeneric species, *Columba leucoptera* Linn. and *C. meloda* Tsch.

Type, by general usage, *Columba leucoptera* Linn., the first species. (Gray, in 1855, designated as the type the second species, *Columba meloda* Tsch.)

Genus **Chæmepelia**.

Chæmepelia Swainson, Zool. Journ., III, Aug.-Nov., 1827, 361.
2 species, *Columba passerina* Linn. and *C. squamosa* Temm.

Type, as designated by Gray (1855) and by elimination, *Columba passerina* Linn., the first species, *C. squamosa* being the type of *Scardafella* Bonap. 1854.

To replace "*Columbigallina* Vaill." Boie, Isis, 1826, p. 977 (not of Oken, 1817), of the Check-List, with the same type. (*Cf.* Stone, Auk, XXIV, April, 1907, p. 192.)

Genus **Scardafella**.

Scardafella Bonaparte, Consp. Av., II, Dec. 1854, 85.
2 congeneric species, *Columba squamosa* Temm. and *Chamæpelia inca* Less.

Type, as designated by Gray (1855) and by general usage, *Columba squamosa* Temm., the first species.

Genus **Geotrygon**.

Geotrygon Gosse, Bds. Jamaica, 1847, 316.
2 congeneric species.

1. *Geotrygon sylvatica* Gosse = *Columba cristata* Temm. & Knip.
2. *Columba montana* Linn.

Type, by implication, as designated by Gray in 1855, and by general usage, *Geotrygon sylvatica* Gosse = *Columba cristata* Temm. & Knip (not *Columba cristata* Gmel. 1788 = *Phasianus roulroul* Scop. 1786).

The proper name of *Geotrygon cristata* is apparently *G. versicolor* (Lafr.) = *Columba versicolor* Lafr., Rev. Zool., 1846, p. 321.

Genus **Starnœnas**.

Starnœnas Bonaparte, Geogr. and Comp. List, 1838, 41.

Monotypic, with *Columba cyanocephala* Linn. as type.

Family CATHARTIDÆ.

Genus **Gymnogyps**.

"*Gymnogyps* Lesson, Echo du Monde savant, ser. 2, VI, 1842, 1037." (Not seen; *cf.* Richmond, Condor, III, 1901, 49.)

Monotypic, with *Vultur californianus* Shaw as type.

Genus **Cathartes**.

Cathartes Illiger, Prodr., 1811, 236.
2 noncongeneric species.

1. *Vultur papa* Linn., type of *Gypagus* Vieill. 1816.
2. " *aura* Linn.

Type, as designated by Vigors (1825) and by elimination, *Vultur aura* Linn., the second species.

By the first species rule, *papa* is the type of *Cathartes* and some other generic designation must be employed for *aura*. (Mr. Stone revives *Rhinogryphus* Ridgw. 1874, to replace *Cathartes* of the Check-List. *Cf.* Auk, XXIV, April, 1907, 198.)

Genus **Catharista**.

Catharista Vieillot, Analyse, 1816, 21.

2 species, and two sections.

1. *Vautour urubu* = *Vultur urubu* Vieill. 1807.
2. *Aura*, Sonnini, édit. de Buffon = *Vultur aura* Linn., type of *Cathartes* Ill. 1811.

Type, by elimination, *Vultur urubu* Vieill. 1807 = *Catharista urubu* Vieill. 1817, the first species.

Genus **Gypagus**.

Gypagus Vieillot, Analyse, 1816, 21.

2 species, 2 sections: (1) "Roi des Vautours, Buff." = *Vultur papa* Linn.; (2) "*Vultur gryffus* Lath." = *gryphus* Linn., type of *Gryphus* Bonap. 1854.

Type, by elimination, *Vultur papa* Linn., the first species.

By the first species rule, *Gypagus* is a synonym of *Sarcorhamphus* Dum. 1806, and of *Cathartes* Ill. 1811, each having the same first species.

Family FALCONIDÆ.

Genus **Elanoides**.

Elanoides Vieillot, Nouv. Dict. d'Hist. Nat., XXIV, 1818, 101.

Monotypic, with "Les Milans de la Caroline et du Paraguay" = *Falco furcatus* Linn. 1766 = *Falco forficatus* Linn. 1758, as type.

Genus **Elanus**.

"*Elanus* Savigny, Descr. de l'Égypte, Ois., 1809, 97"; Ois. de l'Égypte et de la Syrie, 1810, 9, 37. (The 1809 work not seen by me.)

Monotypic, with *Elanus cæsius* Savig. = *Falco melanopterus* Daudin at type.

Genus **Ictinia**.

Ictinia Vieillot, Analyse, 1816, 24.

Monotypic, with "Milan-Cresserell, Vieill. Oiseaux de l'Amér. sept.," I, 1807, 38, pl. 10 *bis* = *Milvus cenchris* Vieill., *l. c.* = *Falco plumbeus* Gmel. as type. (Not *Falco mississippiensis* Wilson, as designated by Gray

(1855) and as given in the Check-List. In 1840 Gray gave *plumbeus* as the type.)

Genus **Rostrhamus.**

Rostrhamus Lesson, Traité d'Orn., 1831, 55.

Monotypic, with *R. niger* Less. = *Herpetotheres sociabilis* Vieill. 1817, as type. (*Falco hamatus* Illiger, given as the type in the Check-List is a later name for the same species.)

Genus **Circus.**

Circus Lacépède, Mem. de l'Inst., III, 1801, 506.

Based on a diagnosis only, with no species referred to the group. Diagnosis not definitely distinctive, indicating merely long-winged hawks with a long slender tarsus, which denote the modern genus *Circus*. Type, as designated by Gray (1855) and by general usage, *Falco cyaneus* Linn.

Genus **Accipiter.**

Accipiter Brisson, Orn., I, 1760, 310.

Type, by tautonomy, [*Accipiter*] *accipiter* Briss. = *Falco nisus* Linn., the first species.

Genus **Astur.**

Astur Lacépède, Mem. de l'Inst., III, 1801, 505.

Based on a diagnosis only, with no species referred to the group. In effect, short-winged hawks with the bill "crochu à l'extrémité." Type, as designated by Vigors (1824) and Gray (1855) and by general consent for three fourths of a century, *Falco palumbarius* Linn.

Genus **Parabuteo.**

Parabuteo Ridgway, in Bd., Brew. & Ridgw., Hist. N. Am. Birds, III, Jan. 1874, 250.

Monotypic, with *Falco harrisi* Aud. as type.

Genus **Buteo.**

Buteo Cuvier, Leç. d'Anat. Comp., I, tabl. ii, 1799.

Proposed for the "Buses." In the same author's Tabl. élément. de l'Hist. nat., 1798, p. 194, of the preceding year, his section "Buses proprement dites," of *Falco*, consists of only *Falco buteo* Linn., which, by tautonomy as well as by general consent for a century, is to be taken as the type of *Buteo*.

Subgenus **Tachytriorchis.**

Tachytriorchis Kaup, Class. Säug. u. Vogel., 1844, 123.

Monotypic, with *Falco pterocles* Temm. = *Buteo albicaudatus* Vieillot as type.

Subgenus **Buteola.**

Buteola Bonaparte, Comp. Rend., XLI, 1855, 651.

"*Buteo brachyurus*, Vieill., est le type du genre buteonien *Buteola*, Dubus." It is thus apparently *Buteola* Bonap. ex Dubus MS.

Monotypic, with *Buteo brachyurus* Vieill. as type.

Genus **Urubitinga.**

Urubitinga Lesson, Rev. Zool., 1839, 132.

Here a *nomen nudum*, but it is also cited as from "Lesson, Compl. d. Buffon, VII, 1836, 36," which work I have not been able to consult.

Type, as designated by Gray (1855), by tautonomy, and by general usage, *Falco urubitinga* Gmel. Stone, on the authority of Dr. Richmond (Auk, XXIV, April, 1907, 195), gives the founder of *Urubitinga* as Lafresnaye, 1843, with type as above indicated.

Genus **Asturina.**

Asturina Vieillot, Analyse, 1816, 24, 68.

Monotypic, with "Esp. nouv. b" = "Asturie cendrée, *Asturia* [sic] *cinerea*" (p. 68) = *Falco nitidus* Gmel. as type.

Genus **Archibuteo.**

Archibuteo Brehm, Isis, Dec. 1828, 1269.

2 nominal species.

1. Der plattköpfige Rauchfussbussard, *Archibuteo planiceps* Brehm = *Falco lagopus* Gmel.
2. Der hochköpfige Rauchfussbussard, *Archibuteo alticeps* Brehm = *Falco lagopus* Gmel.

Monotypic, with *Falco lagopus* Gmel. as type.

Subgenus **Brewsteria.**

Brewsteria Maynard, Bds. East. N. Am., pt. 40, [1896], 691.

Monotypic, with *Falco ferrugineus* Licht. as type.

Genus **Aquila.**

Aquila Brisson, Orn., I, 1760, 419.

Type, by tautonomy, [*Aquila*] *aquila* Briss. = *Falco chrysaëtos* Linn., the first species.

Genus **Thrassaëtos.**

Thrassaëtos Gray, Proc. Zool. Soc. London, 1837 (June, 1838), 108.

Monotypic, with *Thrassaëtos harpyia* = *Vultur harpyia* Linn. as type.

Genus **Haliæetus.**

"*Haliæetus* Savigny, Desc. de l'Égypte, Ois., 1809, 35"; Ois. de l'Égypte et de la Syrie, 1810, 8, 25. (The first not seen by me.)

Monotypic, with *Haliæetus nisus* Savign. = *Falco albicilla* Linn. as type.

Genus **Falco.**

Falco Linnæus, Syst. Nat., ed. 10, 1758, 88.

26 species, of which 6 are synonyms of others of the list, leaving 20 valid species, representing about 13 modern genera.

1. *melanœtus*, same as No. 2.
2. *chrysaëtos*, type of *Aquila* Briss. 1760.
3. *fulvus*, same as No. 2.
4. *canadensis*, same as No. 2.
5. *rusticolus*, a species of *Hierofalco* Cuv. 1817.
6. *barbarus*, a species of restricted *Falco* Linn.
7. *cærulescens*, a species of *Hierax* Vigors, 1824, preoccupied, vice *Microhierax* Sharpe, 1874.
8. *albicilla*, type of *Haliæetus* Savigny, 1809.
9. *pygargus*, a species of *Circus* Lacép. 1799.
10. *milvus*, type of *Milvus* Lacép. 1799.
11. *forficatus*, type of *Elanoides* Vieill. 1818.
12. *gentilis*, same as No. 25.
13. *subbuteo*, type of *Hypotriorchis* Boie, 1826.
14. *buteo*, type of *Buteo* Cuv. 1799.
15. *tinnunculus*, type of *Ægypius* Kaup, 1829, preoccupied, vice *Falcula* Hodgs. 1837.
16. *sufflator*, of doubtful identification; probably same as No. 17.
17. *cachinnans*, type of *Herpetotheres* Vieill. 1817.
18. *sparverius*, type of *Pœcilornis* Kaup, 1844.
19. *columbarius*, type of *Tinnunculus* Vieill., 1807.
20. *lanarius* = *Falco gyrfalco* Linn. 1766.
21. *haliœetus*, type of *Pandion* Savigny, 1809.
22. *gyrfalco*, species of *Hierofalco* Cuv. 1817.
23. *apivorus*, type of *Pernis* Cuv. 1817.
24. *æruginosus*, a species of *Circus* Lacép. 1806.
25. *palumbarius*, type of *Astur* Lacép. 1801.
26. *nisus*, type of *Accipiter* Briss. 1760.

Eighteen of the 26 species were made types of now universally recognized genera prior to 1825, or are synonyms of such types, or are congeneric with them; the remaining 8 have been always referred to *Falco* sens. stric., or to groups now currently referred to it, either as synonyms or as subgenera, according to the views of different authors. Three of these fall into the genus (or subgenus) *Hierofalco* Cuv. 1817; two others come under *Cerch-*

neis Boie, 1826, while of the remaining three, *barbarus*, *subbuteo* and *columbarius*, the latter is the type of *Tinnunculus* Vieill., 1807, recognized in the A. O. U. Check-List as a subgenus of *Falco*; another, *subbuteo*, is the type by tautonomy of *Hypotriorchis* Boie, 1826, a group synonymized by current consent with the restricted group *Falco*; *barbarus* has been sometimes referred to *Gennaia* Kaup, 1847, which group is now not recognized as even a subgenus. Gray (1840), Kaup in (1842), and various subsequent authors, have taken *Falco peregrinus* Latham as the type of the restricted group *Falco*, but as this species was not described till long after *Falco* Linn. was founded it is not eligible as its type.

The A. O. U. Committee, in 1886, in preparing the first edition of the Check-List of North American Birds, designated *Falco subbuteo* Linn. as the type of the restricted genus *Falco*, and there is apparently no reason for rejecting this designation of the type.

Subgenus **Hierofalco.**

Hierofalco Cuvier, Règne Anim., I, 1817, 312.

Type, "le Gerfault" of Brisson = *Falco candicans* Gmel. 1788 = *Falco islandus* Brünn. 1764.

Subgenus **Rhynchodon.**

Rhynchodon Nitzsch, Observ. Av. art. car. com., 1829, 20.

4 noncongeneric species.

1. *peregrinus*.
2. *subbuteo*, type of *Hypotriorchis* Boie, 1826.
3. *æsalon*, type of *Æsalon* Kaup, 1829.
4. *tinnunculus*, type of *Ægypius* Kaup, 1829 (preoccupied) = *Falcula* Hodgs. 1837.

Type, by elimination, *Falco peregrinus* Latham, the first species.

Subgenus **Tinnunculus.**

Tinnunculus Vieillot, Ois. Am. Sept., 1807, 39.

2 species, *columbarius* Linn. and *sparverius* Linn. The second species is congeneric with the type of *Cerchneis* Boie, 1826.

Type, by elimination, *Tinnunculus columbarius* Vieill. = *Falco columbarius* Linn., the first species. (Not *Falco tinnunculus* Linn. as designated by Gray, this being not one of the original species, except by inference.)

Subgenus **Rhynchofalco.**

Rhynchofalco Ridgway, Proc. Boston Soc. Nat. Hist., 1873, 46.

Monotypic, with *Falco femoralis* Temm. as type = *Falco fusco-cœrulescens* Vieill.

Subgenus **Cerchneis.**

Cerchneis Boie, Isis, Oct. 1826, 970.

Monotypic, with *Falco rupicola* Licht. as type.

Genus **Polyborus.**

Polyborus Vieillot, Analyse, 1816, 22.

Monotypic, with "Esp. Caracara, Buff." = *Falco tharus* Mol. as type.

Genus **Pandion.**

"*Pandion* Savigny, Descr. de l'Égypte, Ois., 1809, 95"; Ois. de l'Égypte et de la Syrie, 1810, 9, 35. (The first not seen by me.)

Monotypic, with *Falco haliaëtus* Linn. as type.

Family STRIGIDÆ.

Genus **Strix.**

Strix Linnæus, Syst. Nat., ed. 10, I, 1758, 92.
11 species, representing 7 modern genera.

Auriculatæ.

1. *bubo*, type of *Bubo* Duméril, 1806.
2. *scandiaca*, same as No. 1.
3. *asio*, type of *Scops* Savign. 1809 (preoccupied), and of *Megascops* Kaup, 1829 (also preoccupied); congeneric with type of *Otus* Pennant, 1769.
4. *otus*, type of *Asio* Brisson, 1760.
5. *scops*, congeneric with No. 3.

Inauriculatæ.

6. *aluco* = *flammea* Linn. 766; not *aluco* Linn. 1766.
7. *funerea*, type of *Surnia* Duméril, 1806.
8. *nyctea*, type of *Nyctea* Steph. 1826.
9. *stridula*, same as *aluco* Linn. 1766, type of *Syrnium* Savig. 1809.
10. *ulula*, same as No. 7.
11. *passerina*, type of *Glaucidium* Boie, 1826.

Type, as restricted by Savigny (1809), as designated by Gray (1840), and by elimination, *Strix aluco* Linn. 1758 = *S. flammea* Linn. 1766.

Genus **Asio.**

Asio Brisson, Orn., I, 1760, 477.

Type, by tautonomy, [*Asio*] *asio* Briss. = *Strix otus* Linn., the fourth species.

Genus **Syrnium.**

"*Syrnium* Savigny, Descr. de l'Égypte, Ois., 1809, 298"; Ois. de la Égypte et de la Syrie, 1810, 10, 51. (First work not seen.)

Monotypic, with *Syrnium ululans* Savign. = *aluco* Linn. 1766 (not *aluco* Linn. 1758.)

Genus **Scotiaptex.**

Scotiaptex Swainson, Class. Bds., II, 1837, 217.

2 noncongeneric species, *Strix cinerea* Gmel. and *Strix uralensis* Pall., the latter a species of *Syrnium* Savigny, 1809.

Type, by elimination, *Strix cinerea* Gmel., the first species.

Genus **Cryptoglaux.**

Cryptoglaux Richmond, Auk, XVIII, 1901, 193.

Type, by designation, *Strix tengmalmi* Gmel. To replace *Nyctala* Brehm, 1828, and *Ægolius* Kaup, 1829 (both with same type), preoccupied.

Genus **Otus.**

"*Otus* Pennant, Ind. Zool., 1790, 297," also in an earlier (1769) edition. (Not seen. Accepted on Mr. Stone's authority.)

Monotypic, with *Otus bakkamœna* sp. nov. as the only species. (*Cf.* Stone, Auk, XX, 1903, pp. 273–275.)

Genus **Bubo.**

Bubo Duméril, Zool. Anal., 1806, 34.

"Le ducs (*bubo*) sont les espèces de chouettes à oreilles de Linné." Hence, 5 species, as follows:

1. *bubo.*
2. *scandiaca,* same as No. 1.
3. *asio,* type of *Scops* Savigny, 1809, and of *Megascops* Kaup, 1829, both preoccupied; congeneric with type of *Otus* Latham, 1769.
4. *otus,* type of *Asio* Briss. 1760.
5. *scops,* congeneric No. 3.

Type, as designated by Gray (1840) and Sharpe (1875), by elimination, and by tautonomy, *Strix bubo* Linn.

The genus *Bubo,* as currently employed, has been often considered as = *Otus* Cuvier, 1799 (Leç. d'Anat. Comp., I, tab. ii) where the genus *Strix* Linn. is divided into two groups, (1) "Hibous, *Otus*"; (2) "Chouettes, *Strix,*" which groups may be assumed to correspond with the two Linnæan divisions of *Strix,* "Auriculatæ" and "Inauriculatæ" (see *antea,* p. 333), and that on the principle of tautonomy the type of *Otus* would be *Strix otus* Linn. It appears, however, that the name *Otus* was previously used by Pennant in 1769 for one of the small eared owls congeneric with *Strix scops* Linn. (*Cf.* Stone, Auk, XX, 1903, pp. 272–276.)

Genus **Nyctea.**

Nyctea Stephens, Gen. Zool., XIII, ii, 1826, 62.

2 species, the second a synonym of the first. Hence:

Monotypic, with *Nyctea erminea* Shaw = *Strix nyctea* Linn. as type; hence also tautonymic.

Genus **Surnia.**

Surnia Duméril, Zool. Anal., 1806, 34.

"Le genre surnie (*surnia*) comprend les chouettes à longue queue ou éperviers, la funèbre, la sibérienne, et plusieurs autres." = Hawk Owls.

Essentially monotypic, with *Strix funerea* Linn. (= *ulula* Linn.) as the type.

Genus **Speotyto.**

Speotyto Gloger, Handb. u. Hilfsb. Naturg., 1842, 226.

Monotypic, a provisional generic name for *Strix cunicularia* Molina.

Genus **Glaucidium.**

Glaucidium Boie, Isis, 1826, 970.

2 congeneric species.

1. *Strix nana* "Temm." = King.
2. *Strix passerina* Linn., type of *Noctua* Savigny, 1809 (preoccupied) and of *Athene* Boie, 1822 (preoccupied).

Type, as designated by Gray (1840, not 1855) and by general consent, *Strix passerina* Linn., the second species.

Genus **Micropallas.**

Micropallas Coues, Auk, VI, Jan. 1889, 71.

Monotypic, with *Athene whitneyi* Cooper as type. To replace *Micrathene* Coues, 1866 (preoccupied), with the same type.

Family PSITTACIDÆ.

Genus **Conurus.**

Conurus Kuhl, Consp. Psitt., 1820, 4.

82 species, representing 26 currently accepted modern genera, distributed in 2 families and 4 subfamilies.

Type, by elimination, and as designated by the A. O. U. Committee in the first edition of the Check-List (1886), *Psittacus ludovicianus* Kuhl (ex Gmelin) = *Psittacus carolinensis* Linn.; type by first species rule, *Psittacus guianensis* Kuhl (part) = *Psittacus leucophthalmus* Müll.

In 1891, Salvadori (Cat. Bds. Brit. Mus., XX, p. 203) made *Psittacus carolinensis* Linn. the type of a new genus *Conuropsis*, to which was referred only this species. In November, 1892, the A. O. U. Committee on

Nomenclature referred the case of *Conuropsis* vs. *Conurus* for the Carolina Paroquet to a subcommittee consisting of Dr. Stejneger and the present writer. On careful and independent study of the matter by the two members of the subcommittee they reported (November, 1893) that the type of *Conurus* was, by elimination, *Psittacus carolinensis* Linn., as originally determined by the A. O. U. Committee. This decision was adopted by the Committee (*cf.* Auk, XI, Jan. 1894, p. 49). In the present connection I have gone over the case again with the greatest care and reach the same conclusion.

After reviewing the case at length, the subcommittee closed its report with the following statement: "Salvadori's creation of *Conuropsis* is consequently entirely indefensible under our code. How he came to make it is quite plain, however. He has simply followed Gray in selecting the first species mentioned by Kuhl as the type. Salvadori's genus *Conurus* should therefore under the A. O. U. Code stand as *Psittacara* Vig. and *Conuropsis* as *Conurus* Kuhl (nec Salvadori)."

The leading points of the case are as follows: Kuhl in 1820 (*l. c.*) placed all of the Parrots in the Linnæan genus *Psittacus*, which he divided into sections I–VI, to which he gave names, his restricted group *Psittacus* forming his "Sectio IV." His first section is *Ara* (Cuvier, 1899), in which he placed the Macaws. The second section, which alone concerns us here, he called *Conurus* ("Sectio II, CONURUS. *Perruche* Vaill."). In this section he placed his species No. 11 to No. 92, arranging them in four "subdivisions" under Le Vaillant's French vernacular names. He placed the species in geographical sequence as "A. Americani"; "B. Africani"; "C. Asiatici"; "D. Australes." Owing to the geographical arrangement, the species placed in subdivisions I, III and IV do not follow each other in continuous sequence. His subdivision "II. *Perruche a queue en fleche* Vaill.," contains species 34–40, "Asiatici"; his subdivision "III. *Perruche proprement dit* Vaill.", contains species 17–28 and 30 (American), and 41–92 (Asiatic and Australian), the latter divided into (*a*) Platuri, (*b*) Pezopori, (*c*) Perruche ordinaire.

In 1824, Spix (Av. Bras., I, pp. 29–37) placed 17 species of South American Conures in his new genus *Aratinga*, about half of which belong to the modern genera *Pyrrhura* and *Brotogeris*. In 1825 Vigors (Zool. Journ., II, Oct. 1825, p. 388) proposed a genus *Psittacara*, designating *Psittacus guianensis* "Linn." (= Gmel.) as the type, to which he referred 6 species, including all of those in Kuhl's "Subdivisio I," to which it is exactly equivalent, with the first species of Kuhl's *Conurus* as the designated type. Three months later (*l. c.*, Jan. 1826, p. 519) he had discovered that Spix's genus included some of the same species as his *Psittacara*, and he then restricted

his *Psittacara* to those species having the orbits and a greater or less extent of the cheeks naked, and restricted *Aratinga* to the species having the cheeks and orbits feathered. As thus restricted *Psittacara* and *Aratinga* are both tenable with the type of *Aratinga,* as designated by Bonaparte in 1854 (Rev. et Mag., de Zool., 1854, p. 150) *A. cyanogularis* Spix = *Psittacus cruentatus* Wied, this being the only species positively referred to it by Bonaparte. It thus supercedes Bonaparte's genus *Pyrrhula* of 1856 (Naumannia, 1856, Beilage No. 1, genus 14), which includes 15 species and contains not only *Psittacus cruentatus* Wied, previously assigned by him as the type of *Aratinga,* but five other of Spix's species of this group. Bonaparte here restricted *Aratinga* to *Psittacus guarouba* Gmel., which was already the type and only species of *Guarouba* Less. 1831!

To shorten a long story, it may be sufficient to say that prior to 1885 all the identifiable species placed by Kuhl in *Conurus* had been made the types, or were currently recognized as congeneric with the types, of other genera, except his No. 19, *Psittacus* (*Conurus*) *ludovicianus* Kuhl = *Psittacus carolinensis* Linn., which the A. O. U. Committee was justified in taking as the type, by elimination, of the restricted genus *Conurus.*

Conurus may be briefly considered from still another basis. The first author, after Kuhl, to recognize *Conurus* in either a generic or subgeneric sense was Lesson (Man. Orn., II, 1828, p. 148), who, in 1828, made it his fifth subgenus of *Psittacus,* with type, by designation, "le sincialo, *psittacus rufirostris* L. enl. 550," which is the female of *Palæornis torquata* (Bodd.). *Conurus* Less. 1828, is thus a strict synonym of *Palæornis* Vigors, 1825. Three years later (Traité d'Orn., 1831, p. 211) Lesson made "*Conurus* Kuhl" his seventeenth subgenus of *Psittacus,* which he separated into two "divisions"; the first division comprised his species 95–105, all American, as he understood them[1]; the second (spp. 106–110) included only species of *Palæornis,* which genus he cites as a synonym of his second division of *Conurus.* He indicated no type for either group, but the first species of his first division is *Conurus carolinensis* (Linn.).

Vigors (1825–26), in giving names to the various subdivisions of Kuhl's "section" *Conurus,* evidently did not look upon *Conurus* as anything more than a name for one of Kuhl's six "grand divisions" or "subfamilies" of the family *Psittacidæ* (*cf.* Zool. Journ., II, p. 48, second footnote and p. 58), and not as a name necessarily to be taken as that of a genus or subgenus. Spix treated it in the same way; Wagler, in 1832 (Monographia Psittacorum) evidently held the same view, as he proposed the genus *Sittace* for all the American Conures and allied forms.

[1] Including his "*Conurus rufirostris* (*Psittacus rufirostris,* Gm.; Buff., Enl 550; Levaill. pl. 42"), with "Habite le Brésil" = *Palæornis torquata* (Bodd.).

It was not till 1837 that *Conurus* again figured in nomenclature, when Swainson (Class. Bds., p. 300) used it for three species now placed in as many different genera. His first species is "*C. vittatus* Spix, i, pl. 21," of which apparently the head is figured. In 1840, G. R. Gray (List Gen. and Subgen. Birds, p. 51) again employed it in a broad sense for the American Conures, with *Conurus vittatus* (Shaw) *as the designated type,* which species later became also the type of *Pyrrhura* Bonap. 1856. *Conurus* of Gray comprised the second section of *Macrocercus* Vieill. 1816, *Aratinga* Spix, 1824, *Psittacara* Vigors, 1825, and the greater part of *Sittace* Wagler, 1832. In 1845 Gray (Gen. Bds. II, p. 413, footnote), speaking of "*Conurus* Kuhl," says: "It includes *Aratinga* of Spix (1824), *Psittacara* of Vigors (1825), and *Sittace* of Wagler (1830 [sic])." Bonaparte, in 1850 (Consp. Av., I, p. 1), employed "*Conurus* Kuhl" in a generic sense, with the same synonymy as given by Gray in 1840, but he cited under it only two species, *Psittacus carolinensis* Linn. and *Conurus xanthogenius* sp. nov. (= *Psittacus pertinax* Linn.).

In 1855, Gray (Cat. Gen. and Subg. Bds., p. 37) divided *Conurus* into 12 subgenera, two of which he left unnamed. Of the restricted group *Conurus* he designated "*Psittacus guianensis* Linn." as the type; as Linnæus had no "*Psittacus guianensis*," presumably *Psittacus gujanensis* Gmelin is meant = *P. leucophthalmus* Müll. *Psittacara* Vigors, 1825, *with the same type by designation of the author,* is given as a synonym, while *Aratinga* Spix is recognized as a subgenus, with *Psittacus luteus* Bodd. as type. Gray has here done just what Vigors proposed to do in 1826 (Zool. Journ., II, Jan. 1826, p. 519) — given recognition to both of the two groups *Psittacara* and *Aratinga,* but he had no right to designate as the type of his restricted subgenus *Conurus* the type designated by the author of *Psittacara* as its type thirty years before; especially as he had himself designated, fifteen years before, as the type of *Conurus* a species for which he left an unnamed subgenus (No. 1475), which Bonaparte a few years later named *Pyrrhula.* Four years later (Cat. Psittacidæ, 1859, pp. 31–47), Gray recognized these same 12 subgenera and two others, adopting Bonaparte's *Pyrrhula* of 1856 for the subgenus containing, as one of its components, the species designated by him in 1840 as the type of *Conurus!* An author however, has no more right to change his designation of a type than he has to transfer a generic name, his own or otherwise, to a group generically different from that for which it was orignally proposed.

Salvadori's 'Catalogue of the Psittaci, or Parrots' is a most admirable piece of work from all points of view except one — that of nomenclature. The tendency since its publication, a decade and a half ago, has been steadily away from the nomenclatural standpoint shared by Salvadori in 1891

with so many others. His nomenclatural starting point was not only 1766 instead of 1758, but he discarded names erroneously constructed, or of barbarous origin, or of false signification,[1] thus adopting many names untenable under the rule of priority, as well as under other rules of present day codes of nomenclature. The nomenclature of the Psittaci, as adopted by Salvadori and as still to a large extent current, is much in need of revision, wholly aside from the question of whether the types of genera are to be decided by a first species rule or the priority method. Already *Amazona*, rejected by Salvadori for the later *Chryotis*, is in nearly universal use. *Psittacara* Vigors (1825) was carefully defined, with a type by designation of the author; the only reason for rejecting it is that the name is a 'vox hybrida,' which under present nomenclature rules is no reason at all.

Genus **Rhynchopsitta.**

Rhynchopsitta Bonaparte, Rev. et Mag. Zool., VI, 1854, 149.

Monotypic, with *Macrocercus pachyrhynchus* Swains. as type.

Family CUCULIDÆ.

Genus **Crotophaga.**

Crotophaga Linnæus, Syst. Nat., ed. 10, I, 1758, 105.

Monotypic, with *Crotophaga ani* Linn. as type.

Genus **Geococcyx.**

Geococcyx Wagler, Isis, 1831, 524.

Monotypic, with *Geococcyx variegata* sp. nov. = *Saurothera californiana* Less. as type.

Genus **Coccyzus.**

Coccyzus Vieillot, Analyse, 1816, 28.

Monotypic, with "Coucou de la Caroline, Buff." = *Cuculus americanus* Linn. as type.

Genus **Cuculus.**

Cuculus Linnæus, Syst. Nat., ed. 10, I, 1758, 110.

8 species, representing 7 modern genera and 3 families.

1. *canorus.*
2. *persa*, a species of *Turacus* Cuv. 1799.
3. *vetula*, type of *Saurothera* Vieill. 1816.
4. *glandarius*, type of *Coccystes* Gloger, 1842.
5. *scolopaceus* = *C. honoratus* Linn. 1766, type of *Eudynamys* V. & H., 1826.

[1] *Cf.* Auk. IX, July 1892, pp. 277–279.

6. *niger*, same as No. 5.
7. *americanus*, type of *Coccyzus* Vieill. 1816.
8. *auratus* = *Picus auratus* Linn. 1766, type of *Colaptes* Swains. 1827.

Type, as designated by Gray (1840), by general consent, and by elimination, *Cuculus canorus* Linn., the first species.

Family TROGONIDÆ.

Genus **Trogon.**

Trogon Brisson, Orn., IV, 1860, 164.

6 species, all belonging to the modern genus *Trogon*, and representing only one identifiable valid species. One of the few non-tautonymic genera of this author.

1. *Trogon cayanensis cinereus* = *Trogon strigilatus* Linn.
2. *Trogon cayanensis viridis* = *Trogon viridis* Linn.
3. *Trogon cayanensis viridis ventre candido* = *Trogon viridis* Linn.
4. *Trogon brasiliensis viridis* = *Trogon curucui* Linn. ? = *T. collaris* Vieill.
5. *Trogon mexicanus*, not identifiable.
6. *Trogon mexicanus varius*, not identifiable.

Trogon Linn., 1766, is based on *Trogon* Brisson, 1760. Linnæus's three species (two of which are based on Brisson, wholly, and the other in part) are reducible to one valid species, commonly known as *Trogon viridis* Linn. = *strigilatus* Linn. (which comes first on the same page), the type of the genus, which is in reality monotypic.

Family ALCEDINIDÆ.

Genus **Ceryle.**

Ceryle Boie, Isis, 1828, 316.

5 congeneric species, separated into several modern subgenera.

1. *rudis*.
2. *amazona*, a species of *Chloroceryle* Kaup, 1848.
3. *americana*, a species of *Chloroceryle*.
4. *alcyon*, a species of *Megaceryle* Kaup, 1848.
5. *bicolor* = *inda* Linn., a species of *Chloroceryle*.

Type, as designated by Gray (1840) and by elimination, *Alcedo rudis* Linn., the first species. In 1848, Kaup removed three of the species to his *Chloroceryle* and one to his *Megaceryle*, leaving only the first species in *Ceryle*.

[Genus **Alcedo.**

Alcedo Linnæus, Syst. Nat., ed. 10, 1758, I, 115.

7 species (1 not determinable), representing 5 modern genera.

1. *ispida*, type of *Ispida* Briss. 1760.
2. *erithaca*, not determinable.
3. *alcyon*, congeneric with No. 6.

4. *todus*, type of *Todus* Briss. 1760.
5. *smyrnensis*, a species of *Halcyon* Swains. 1820.
6. *rudis*, type of *Ceryle* Boie, 1828.
7. *dea*, type of *Tanysipterus* Vigors, 1825.

Type, by elimination, *Alcedo rudis* Linn., the sixth species.

Brisson's genus *Ispida* (Orn., IV, 1760, p. 471) appears to have been overlooked or ignored by subsequent writers, as have several other of his properly proposed genera, as *Buphagus, Trogon, Todus, Anhima, Cochlearius, Raphus,* and *Muscicapa,* which all have the same standing as the many others that have been almost universally adopted, but in some cases wrongly attributed to Linnæus (1766). Brisson's genus *Ispida* contained only Kingfishers; Linnæus's genus *Alcedo* contained, at 1758, both Kingfishers and Todies; at 1766 the Todies were removed and the Jacamars added, so that *Alcedo,* 1758 = *Ispida* + *Todus* Brisson, and in 1766 = *Ispida* + *Galbula* Brisson.

The genus *Ispida* contained originally 26 species, including all of the six species of Kingfisher placed by Linnæus in *Alcedo,* besides seven described by Linnæus in 1766, and six others named later by Gmelin in 1788, all on the basis of Brisson and his citations; some of the remaining seven were made the basis of 'varieties,' or were considered duplications of those to which Linnæus and Gmelin, respectively, gave names.

Applying the rule of tautonomy and elimination to these genera, *Alcedo ispida* Linn., becomes the type of *Ispida* Brisson, and *Alcedo todus* Linn., becomes the type of *Todus* Brisson. Of the four remaining valid species, the last one to be removed was *Alcedo rudis* Linn., which became the type of *Ceryle* Boie in 1828. Therefore *Alcedo* should replace *Ceryle,* with the result that two of the six original Linnæan species would still remain in *Alcedo,* and *Alcedo* would replace *Ceryle* in the Check-List.]

Subgenus **Streptoceryle.**

Streptoceryle Bonaparte, Consp. Vol. Anisod., 1854, 10.
2 congeneric species, *torquata* Linn. and *alcyon* Linn.

Type, as designated by Gray (1855) and by Sharpe (Jan. 1871 and 1892), *Alcedo torquata* Linn., the first species.

Subgenus **Chloroceryle.**

Chloroceryle Kaup, Fam. Eisv., 1848, 8.
5 (4 valid) species, all currently considered as subcongeneric.
1. *superciliosa.* 2. *americana.* 3. *inda.*
4. *amazona,* type of *Amazonis* Reich. 1851 (not *Amazona* Less. 1831).
5. *bicolor,* same as No. 3.

Type, as designated by Sharpe (1871 and 1892), *Alcedo superciliosa*

Linn., the first species; as designated by Gray (1855), *Alcedo amazona* Lath., the fourth species.

Family PICIDÆ.

Genus **Campephilus.**

Campephilus Gray, List Gen. Bds., 1840, 54.

Monotypic, with *Picus principalis* Linn. as type.

Genus **Dryobates.**

Dryobates Boie, Isis, 1826, 977.

Monotypic, with *Picus pubescens* Linn. as type.

Genus **Xenopicus.**

Xenopicus Baird, Bds. N. Am., 1858, 83.

Monotypic, with *Leuconerpes albolarvatus* Cass. as type.

Genus **Picoides.**

Picoides Lacépède, Mem. de l'Inst., III, 1801, 509.

Based on a diagnosis, indicating Woodpeckers with only three toes on each foot. As the northern three-toed Woodpeckers are the only tridactyle Woodpeckers then known, the type is obviously *Picus tridactylus* Linn., as designated by Gray (1840), and the genus monotypic.

Genus **Sphyrapicus.**

Sphyrapicus Baird, Bds. N. Am., 1858, 101.

Type, by designation (*l. c.*, p. 102), *Picus varius* Linn.

Genus **Ceophlœus.**

Ceophlœus Cabanis, Journ. f. Orn., 1862, 176.

4 species, 3 of them congeneric. Ostensibly to replace *Hylatomus* Baird, 1858, preoccupied.

Type, by designation, *Picus lineatus* (Linn.), while the type of *Hylatomus* is *Picus pileatus,* which the next year (Mus. Hein., pt. IV, 1863, p. 102) Cabanis made the type and only species of his genus *Phlœotomus,* which is thus available in place of *Ceophlœus.*

In the British Museum Catalogue of Birds (XVIII, 1890, p. 514) *Dryotomus* Swainson (Faun. Bor.-Am., II, 1831, 1832) is employed for *Picus pileatus* alone, but as the type of *Dryotomus* was designated by the author as *Picus martius* Linn., a species noncongeneric with *P. pileatus, Dryotomus* is obviously not available in this connection.

Genus **Melanerpes.**

Melanerpes Swainson, Faun. Bor.-Am., II, 1831 (1832), 300, 316.

Monotypic, with type by designation (p. 316), *Melanerpes erythrocephalus* Swains. = *Picus erythrocephalus* Linn.

Genus **Asyndesmus.**

Asyndesmus Coues, Proc. Acad. Nat. Sci. Phila., 1866, 55.

Monotypic, with *Picus torquatus* Wils. as type.

Genus **Centurus.**

Centurus Swainson, Class. Bds., II, 1837, 310.

2 species, *C. carolinensis* Wils. and *C. brachypterus*, sp. nov., the latter a *nomen nudum*.

Monotypic, with *Picus carolinus* Linn. as type.

Genus **Colaptes.**

Colaptes Swainson, Phil. Mag. (2), I, June, 1827, 440, only species *Colaptes mexicanus* sp. nov. with a reference to "*Swains. Zool. Journ.* No. 10"; Zool. Journ. III, Aug.–Nov. 1827, 353, where the type is designated as "*Picus auratus*, Wilson, I, pl. 2, fig. 1" = *Cuculus auratus* Linn.

Type, by designation, *Cuculus auratus* Linn.

Family CAPRIMULGIDÆ.

Genus **Antrostomus.**

"*Antrostomus* Gould" Bonaparte, Geogr. and Comp. List Bds. Eur. and N. Amer., 1838, 8.

2 congeneric species.

1. *carolinensis*; 2, *vociferus*.

Type, as designated by Gray (List Gen. Bds., 1840, p. 7), *Caprimulgus carolinensis* Gmel., the first species. The reference in the Check-List to "Gould, Icones Avium, 1838" is erroneous, as neither the genus nor any of its species occur there. In the 'British Museum Catalogue' the genus is wrongly ascribed to Nuttall, 1840.

Genus **Phalænopterus.**

Phalænopterus Ridgway, Proc. U. S. Nat. Mus., III, 1880, 5.

Monotypic, with *Caprimulgus nuttalli* Aud. as type.

Genus **Nyctidromus.**

Nyctidromus Gould, Icones Avium, II, 1838, pl. ii.

Monotypic, with *Nyctidromus derbyanus* sp. nov. = *Caprimulgus albicollis* Gmel. as type, and the only species explicitly mentioned. He adds: "There are at least ten species of this peculiar form," all confined to South America, but no others are cited.

Genus **Chordeiles.**

Chordeiles SWAINSON, Faun. Bor.-Am., II, 1831, 337, 496.

Monotypic, with *Chordeiles virginianus* = *Caprimulgus virginianus* Gmel. as type.

Family MICROPODIDÆ.

Genus **Cypseloides.**

Cypseloides STREUBEL, Isis, 1848, 366.
2 congeneric species.

1. *Hemiprocne fumigata* = *Cypselus fumigatus* Natterer MS.
2. *Cypselus senex* Temm.

Type, as designated by Sclater (P. Z. S., 1865, p. 614), and by general consent, *Hemiprocne fumigata* Streubel, the first species.

Genus **Chætura.**

Chætura STEPHENS, Gen. Zool., XIII, pt. ii, 1825, 76.
6 species, 5 of them congeneric.

1. *pelasgia* = *pelagica* Linn.
2. *martinicana* = *acuta* Gm.
3. *pacifica*, a species of *Micropus* Meyer & Wolf, 1810.
4. *australis* = *caudacuta* Lath.
5. *fusca* = *caudacuta* Lath.
6. *collaris* = *zonaris* Shaw.

Nos. 2, 4, 5, and 6 are congeneric with No. 1.

Type, by current usage, *Hirundo pelagica* Linn., the first species. (The type designated by Gray (1855) is not one of the original species, as it was not described till fourteen years after the genus was founded.)

Genus **Aëronautes.**

Aëronautes HARTERT, Cat. Bds. Br. Mus., XVI, 1892, 459.

Monotypic, with *Cypselus melanoleucus* Baird as type.

Family TROCHILIDÆ.

Genus **Eugenes.**

Eugenes GOULD, Mon. Troch., pt. xii, 1856, pl. 59.

Monotypic, with *Trochilus fulgens* Swains. as type.

Genus **Cœligena**.

Cœligena Lesson, Ind. and Synop. gen. Trochil., 1832, p. xviii.
3 noncongeneric species.

1. *clemenciæ*, type of *Cyanolæma* Stone, 1907.
2. *cœligena*.
3. *rivoli* = *T. fulgens* Swains. 1827, type of *Eugenes* Gould, 1856.

Type, by tautonomy, and as designated by Bonaparte in 1850 (Synop. Av., p. 73), *Ornismya* (*Cœligena*) *cœligena* Lesson. Usually *O. clemenciæ* Less., the first species, has been taken as the type, as designated by Gray. This species being noncongeneric with the proper type of *Cœligena*, and not being referable elsewhere becomes the type of *Cyanolæma* Stone, 1907, (*cf.* Stone, Auk, XXIV, April, 1907, p. 196).

Genus **Trochilus**.

Trochilus Linnæus, Syst. Nat., ed. 10, I, 1758, 119.
18 species, nearly all noncongeneric, and nearly one-half of them unidentifiable.

Type, as designated by Gray (1855) and by general consent, *Trochilus colubris* Linn., the sixth species.

Strict elimination would apparently make the type *Trochilus mellivorus* Linn., the type of *Florisuga* Bonap. 1850; by the first species rule, the genus *Trochilus* would be cancelled, the first species being unidentifiable.

Genus **Calypte**.

Calypte Gould, Mon. Troch., III, 1856, 134.
3 species, representing 2 genera.

1. *costæ*.
2. *annæ*, type of *Atthis* Reich. 1853.
3. *helenæ*, congeneric with No. 1.

Type, as designated by Elliot (1879) and by general consent, *Ornismya costæ* Bourc., the first species.

Genus **Selasphorus**.

Selasphorus Swainson, Faun. Bor.-Am., II, 1831 (Feb. 1832), 324 (first mentioned), 496 (diagnosis).
4 species, representing 2 genera.

1. *rufus*.
2. *chalybeus*, congeneric with No. 3.
3. *ornatus*, type of *Lophornis* Lesson, 1829.
4. *platycercus*, congeneric with No. 1.

Type, *Trochilus rufus* Gmel., as designated by Gray (1855), the first species, it best agreeing with the diagnosis ("feathers of the neck [= throat]

elongated"), a feature present in *rufus* and absent in *platycercus*. Furthermore, a reference to the index of the volume shows that *rufus* was intended as the type, as we there find *Selasphorus rufus* only, no other species of *Selasphorus* being indexed.

Genus **Atthis**.

Atthis Reichenbach, Aufz. der Colib. (Journ. f. Orn., 1853, Extraheft) 1853, 12.
3 species, representing 2 genera.

1. *heloisa* Less. & Delatt.
2. *costæ* Bourc., type of *Calypte* Gould, 1861.
3. *annæ* Less., congeneric with No. 2.

Type, as designated by Gray (1855) and by general consent, *Ornismya heloisæ* Less. & Delatt., the first species.

Genus **Stellula**.

Stellula Gould, Introd. Troch., 1861, 90.

Monotypic, with *Calothorax calliope* Gould as type.

Genus **Calothorax**.

Calothorax Gray, List Gen. Bds., 1840, 13.

Monotypic, with *Ornismya cyanopogon* Less. = *Trochilus lucifer* Swains. 1827, as type.

Genus **Amizilis**.

Amizilis Gray, List Gen. Bds., 1840, 14.
2 noncongeneric species.

1. *Cynanthus latirostris* Swains., type of *Cynanthus* Swains. 1827, and of *Circe* Gould, 1857 (preoccupied) = *Iache* Elliot, 1879.
2. *Orthorhynchus amazili* Less.

Type, as designated by the author in 1855 (not 1840), by tautonomy, and by elimination, *Ornismya amizili* Less. By the first species rule, *Amizilis* Gray is a synonym of *Cynanthus* Swains. 1827 (Phil. Mag. (2), I, June, 1827, p. 441).

Amazilis has sometimes been incorrectly attributed to Lesson, 1832, but Lesson used the tern only in a vernacular sense for a group of four congeneric species which he termed "Les Amazilis," based on the name of the first species of the group, *Ornismya amazili* Less. *Amazilia* Reichenbach, 1849, is a substitute or emended name for the same group. By the first species rule, however, *Amazilia* Reich. is a synonym of *Cynanthus* Swains., both genera having the same first species.

Genus **Cynanthus**.

Cynanthus Swainson, Phil. Journ. (2), June, 1827, 441.
4 noncongeneric species.

1. *latirostris*, sp. nov., type of *Circe* Gould, 1857 (preoccupied), and of *Iache* Elliot, 1879.
2. *bifurcatus* = *nuna* Less., type of *Lesbia* Less. 1832.
3. *minimus* sp. nov.[1] ? = *T. minimus* Linn., type of *Melissuga* Briss. 1760.
4. *lucifer* sp. nov., type of *Calothorax* Gray, 1840.

Type, by elimination, *Cynanthus latirostris* Swains., the first species.

If "*Cyanomyia ? sordida* Gould" is congeneric with *Cynanthus latirostris* Swains., as several recent authorities consider it to be, then *Phœoptila* Gould, 1861, is also, as well as *Iache*, a synonym of *Cynanthus*.

Cynanthus as now, and for a long time past, currently used in ornithology is taken from Swainson, 1837 (Class. Bds., II, 1837, p. 330) instead of from Swainson 1827; at the later date it was monotypic and based on a species ("*C. forficatus auct.*") which was not one of its original constituents.

Genus **Basilinna**.

Basilinna Boie, Isis, 1831, 546.

6 species, representing 5 genera.

1. *leucotis*.
2. *albicollis*, type of *Leucochloris* Reich. 1854.
3. *mellivorus*, type of *Florisuga* Bonap. 1850.
4. *tephrocephalus*, a species of *Agyrtria* Reich. 1854.
5. *leucogaster*, congeneric with No. 4.
6. *albus*, a species of *Lampornis* Swains. 1827.

Type, by elimination, and as designated by Gray (1855), *Trochilus leucotis* Vieill.

Genus **Iache**.

Iache Elliot, Class. and Synop. Troch., March 1879, 234.

4 congeneric species.

Type, by designation, *Cynanthus latirostris* Swains., to replace *Circe* Gould, 1857 (preoccupied), with same type.

Both by first species rule and by elimination *Iache* is a synonym of *Cynanthus* Swainson, June, 1827, which has thirty years priority even over *Circe* Gould. Consequently *Cynanthus* must replace *Iache* in the A. O. U. Check-List.

Family COTINGIDÆ.

Genus **Platypsaris**.

Platypsaris Sclater, Proc. Zool. Soc. Lond., 1857, 72 (*ex* Bonaparte, Ann. Sci. Nat., 1854, 134 = *nomen nudum*).

7 species, of which 2 are nominal and 2 belong to other genera, as now treated.

[1] "Table land" of Mexico, but locality apparently wrong, as the description indicates a young male of *Melissuga minima* (Linn.). I can find no subsequent reference to *Cynanthus minimus* Swains.

Type, as provisionally fixed by Gray (1855) and adopted by Sclater (*l. c.*), *Pachyrhamphus latirostris* Bonap. = *Pachyrhynchus aglaiæ* Lafr., the sixth species. (*Hadrostomus* Cabanis, 1859, is practically a substitute name for *Platypsaris*.)

Family TYRANNIDÆ.

Genus **Muscivora**.

"*Muscivora* Lacépède, Discours d'Hist. Nat., 1799, 5." (Not seen.)

At this point "*Muscivora* Lacépède" has no standing. As pointed out to me by Mr. Stone, it can be taken from G. Fischer (Zoognosia, ed. 3, I, 1813, p. 54), where, with a brief diagnosis, "*M*[*uscicapa*] *forficata*" is designated as the type.

Genus **Tyrannus**.

Tyrannus Cuvier, Leç. d'Anat. Comp., I, 1799, tab. ii.

Proposed for the "Tyrans" as distinguished from the "Moucherolles" (*Muscipeta* Cuv.) and the "Gobe-mouche" (*Muscicapa* Cuv. *ex* Linn.). (*Cf.* Cuvier, Tabl. élément. de l'Hist. nat des Anim., 1797, p. 201.)

The genus appears to have been first employed, after 1799, by Vieillot (Ois. Am. Sept., I, 1807 [1808], pp. 72–79) in 1808, who included in it 7 species, representing 5 modern genera, of which the second was *Tyrannus pipirri* Vieill. = *Lanius tyrannus* Linn. Cuvier, in 1817 (Règne Anim., I, 1817, p. 344), also referred to it 7 species, representing 5 modern genera, of which *Lanius tyrannus* Linn. was the third species.

Type, by tautonomy, as designated by Gray (1840), and also by general consent, *Lanius tyrannus* Linn.

Genus **Pitangus**.

Pitangus Swainson, Zool. Journ., III, April–July, 1827, 165.

Monotypic, with *Tyrannus sulphuratus* Vieill. as type by designation.

Genus **Myiozetetes**.

Myiozetetes Sclater, Proc. Zool. Soc. Lond., 1852, 46 (ex *Myiozeta* Bonap., Ann. Sci. Nat., IV, 1854, 134 = *nomen nudum*).

Type, as fixed by Sclater (*l. c.*) *Elainia cayennensis* auct. = *Muscicapa cayennensis* Linn.

Genus **Myiodynastes**.

Myiodynastes Bonaparte, Compt. Rend., XXXVIII, 1854, 657, *nomen nudum*; "Bull. Soc. Linn. Normandie, II, 1857, 35."

Type, as designated by Sclater (P. Z. S., 1859, p. 42), and by general consent, *Tyrannus audax* Gmel.

Genus **Myiarchus.**

Myiarchus Cabanis, Wiegm. Arch. f. Naturg., 1844, I, 272.
6 species, representing 5 modern genera.

1. *ferox.*
2. *rufiventris,* type of *Myiotheretes* Reich. 1850 (*fide* Sclater).
3. *nigricans,* type of *Sayornis* Bonap. 1854, and of *Aulanax* Cab. 1856.
4. *ferrugineus,* a species of *Hirundinea* D'Orb. & Lafr. 1837.
5. *coronatus,* a species of *Pyrocephalus* Gould, 1841.
6. *atropurpureus,* congeneric with No. 5.

Type, by elimination, as designated by Gray (1855), and as currently accepted, *Muscicapa ferox* Linn., the first species.

Genus **Sayornis.**

Sayornis Bonaparte, Ann. Sc. Nat. (4), I, 1854, 133 (*nomen nudum*); Coll. Delattre, 1854, 87, where it is given as "*Sayornis nigricans* Bp.," with nothing additional.

Monotypic, with *Tyrannula nigricans* Swains. as type. There is apparently no reasonable doubt as to the signification of "*Sayornis nigricans* Bp."; if there is, *Sayornis* can be taken from Gray, 1855 (Cat. Gen. and Subgen. Bds., 1855, p. 146) with *Tyrannula saya* Bonap., a congeneric species, as type both by designation and by tautonomy.

Genus **Nuttallornis.**

Nuttallornis Ridgway, Man. N. Am. Bds., 1887, 337.

Monotypic, with *Tyrannus borealis* Swain. as type.

Genus **Horizopus.**

Horizopus Oberholser, Auk, XVI, 1899, 311.

Type, by designation, *Muscicapa virens* Linn. (To replace *Contopus,* preoccupied, with same type.)

Genus **Empidonax.**

Empidonax Cabanis, Journ. f. Orn., 1855, 480.

Monotypic, with *Tyrannula pusilla* Swains. as type.

Genus **Pyrocephalus.**

Pyrocephalus Gould, Zool. Voy. Beagle, II, Birds, 1841, 44.
2 congeneric species, (1) *parvirostris* Gld., described and figured, and (2) *Muscicapa coronata* auct.

The type should obviously be *Pyrocephalus parvirostris* Gould, the species figured; type as fixed by Gray (1840) and by general usage, *M. coronata*, the second species.

Genus **Ornithion.**

Ornithion Cabanis, Journ. f. Orn., 1853, 35.

Monotypic, with *Ornithion inerme* sp. nov. as type.

Family ALAUDIDÆ.

Genus **Alauda.**

Alauda Linnæus, Syst. Nat., I, ed. 10, 1758, 165.
9 species, representing 6 modern genera.

1. *arvensis.*
2. *pratensis*, congeneric with No. 5.
3. *arborea*, type of *Lullula* Kaup, 1829.
4. *campestris*, type of *Agrodoma* Swains. 1837; congeneric with No. 5.
5. *trivialis* (= *arboreus* Bechst.), type of *Anthus* Bechst. 1807.
6. *cristata*, type of *Galerida* Boie, 1828.
7. *spinoletta*, congeneric with No. 5.
8. *alpestris*, type of *Otocoris* Bonap. 1838.
9. *magna*, type of *Sturnella* Vieill. 1816.

Nos. 2, 4, and 7 are congeneric with No. 5, the type of *Anthus* Bechst.

Type, by elimination, as designated by Gray (1840), and by universal consent, *Alauda arvensis* Linn., the first species.

Genus **Otocoris.**

Otocoris Bonaparte, Nouvi Ann. Sci. Bologna, II, 1838, 407.

Monotypic, with *Phileremos cornutus* Bonap. (= *Alauda chrysolæma* ? Wagler) as type, a subspecies of *Alauda alpestris* Linn., given as the type in the Check-List.

Family CORVIDÆ.

Genus **Pica.**

Pica Brisson, Orn., II, 1760, 35.

Type, by tautonomy, [*Pica*] *pica* Briss. = *Corvus pica* Linn., the first species.

Genus **Cyanocitta.**

Cyanocitta Strickland, Ann. and Mag. Nat. Hist., XV, 1845, 261.
5 species referred to it.

Type, as designated by the author, *Corvus cristatus* Linn.

By the first species rule *Cyanocitta* would be a synonym of *Cyanurus* Swains., 1831, except that *Corvus cristatus* Linn., the first species, is said to be not typical.

Cyanurus Swainson, included, as originally founded (Faun. Bor.-Am., II, 1831, 495), 10 species, as follows:

1. *cristatus*, type of *Cyanocitta* Strickl. 1845.
2. *stelleri*, congeneric with No. 1.
3. *sordidus* Swains. = *sieberi* Wagler, 1827, currently referred to *Aphelocoma* Cab. 1851.
4. *floridanus* Bonap. = *cyanea* Vieill., currently referred to *Aphelocoma*.
5. *coronatus* Swains., subspecies of No. 2.
6. *cyanopogon* Wied, currently considered as congeneric with *Cyanocorax* Boie, 1826.
7. *pileatus* Temm., type of *Cyanocorax* Boie, 1826.
8. *azureus* Vieill., referred by Strickland to his *Cyanocitta*, but considered by later authors as aberrant.
9. *formosus* Swain. (= *Pica bullocki* Gray), type of *Callocitta* Gray, 1841.
10. *cristatellus* Temm., type of *Uroleuca* Bonap. 1850, as restricted by Cabanis in 1851.

Cyanurus Swains. is treated by most authors as a synonym of *Cyanocorax* Boie, 1826. According to Sharpe (*cf.* Brit. Mus. Cat. Bds., III, 1877, p. 119, footnote), if used at all, it is available only for *azureus*, usually regarded as doubtfully congeneric with *Cyanocorax*.

As already said, by the first species rule it would replace *Cyanocitta* of the A. O. U. Check-List for the large group of species and subspecies so long known under the latter name. It is objected that in this case the first species cannot be taken as the type, because the author stated that "the three first species are aberrant"; then by the first species rule the type is the fourth species, and hence *Cyanurus* must replace *Aphelocoma*.

Genus **Aphelocoma**.

Aphelocoma Cabanis, Mus. Hein., I, 1851, 221.
4 congeneric species, as follows:

1. *californica*,
2. *sieberi*,
3. *ultramarina*,
4. *floridana*.

Type, as determined by Sharpe (Br. Mus. Cat. Bds., III, 1877, p. 112), and as since currently recognized, *Garrulus californicus* Vigors, the first species. (Gray, 1855, made *Aphelocoma* a synonym of *Cyanocitta*, with *Garrulus californicus* Vigors as the type of *Cyanocitta*, a species inferentially excluded from the group by the original author, who, besides, explicitly designated a different species as the type.)

Genus **Xanthoura**.

Xanthoura Bonaparte, Consp. Av., I, 1850, 380.

3 species, all currently recognized as congeneric, namely: (1) *peruanus*, (2) *luxuosus*, (3) *guatemalensis*.

Type, as fixed by Gray (1855), and by general consent, *Corvus peruanus* Gmel. = *C. yncas* Bodd., the first species.

Genus **Perisoreus**.

Perisoreus Bonaparte, Saggio Dist. Metod. Anim. Vertebr., 1831, 43.

3 species, 2 of them congeneric and 1 undescribed, as follows: (1) *infaustus*, (2) *canadensis*, (3) "sp. nov." undesc.

Type, by general consent, *Corvus infaustus* Linn.; type designated by Gray (1840, also 1855), *Corvus canadensis* Linn.

Genus **Corvus**.

Corvus Linnæus, Syst. Nat., ed. 10, I, 1758, 105.

12 species, representing 10 modern genera.

1. *corax*.
2. *corone*, type of *Corone* Kaup, 1829.
3. *frugilegus*, type of *Trypancorax* Kaup, 1854.
4. *cornix*, congeneric with No. 1.
5. *monedula*, type of *Coleus* Kaup, 1829.
6. *benghalensis* = *Coracias bengalensis* Linn. 1766.
7. *glandarius*, type of *Garrulus* Briss. 1760.
8. *cristatus*, type of *Cyanocitta* Strickl. 1845.
9. *caryocatactes*, type of *Nucifraga* Briss. 1760.
10. *pica*, type of *Pica* Briss. 1760.
11. *paradisi*, type of *Terpsiphone* Gloger, 1827.
12. *infaustus*, type of *Perisoreus* Bonap. 1838.

Nos. 2 and 4 are commonly considered as congeneric with No. 1.

Type, as designated by Gray (1840), by elimination, and by common consent, *Corvus corax* Linn., the first species.

Genus **Nucifraga**.

Nucifraga Brisson, Orn., II, 1760, 58.

Monotypic, with [*Nucifraga*] *nucifraga* Brisson = *Corvus caryocatactes* Linn. as type; also tautonymic.

Genus **Picicorvus**.

Picicorvus Bonaparte, Consp. Av., I, 1850, 384.

Monotypic, with *Corvus columbianus* Wils. as type.

Genus **Cyanocephalus**.

Cyanocephalus Bonaparte, Oss. Stat. Zool. Europ. Vert., 1842, 17.

Monotypic, with *Gymnorhinus cyanocephalus* Wied as type; hence tautonymic.

Family STURNIDÆ.

Genus **Sturnus.**

Sturnus Linnæus, Syst. Nat., ed. 10, I, 1758, 167.
4 species, representing 3 genera and 2 families.

1. *vulgaris.*
2. *luteolus,* not identifiable.
3. *contra,* type of *Sturnopastor* Hodgs. 1844.
4. *cinclus,* type of *Cinclus* Bechst. 1802.

Type, as designated by Gray (1840), by elimination, and by general usage, *Sturnus vulgaris* Linn., the first species.

Family ICTERIDÆ.

Genus **Dolichonyx.**

Dolichonyx Swainson, Phil. Mag. (2), I, June, 1827, 435; with a reference to "*Swains. Zool. Journ.,* No. 10." One species, "*Emberiza oryzivora* Wils."

Dolichonyx Swainson, Zool. Journ., III, Aug.–Nov., 1827, 351. Diagnosis, and type designated as *Emberiza oryzivora* Wils. = *Fringilla oryzivora* Linn.

Monotypic, with type by designation, *Fringilla oryzivora* Linn.

Genus **Molothrus.**

Molothrus Swainson, Faun. Bor.-Am., II, 1831 (Feb. 1832), 277 (first mentioned), 494 (diagnosis, and type designated).

Monotypic, with *Fringilla pecoris* Gmel. = *Oriolus ater* Bodd. as type by designation.

Genus **Tangavius.**

Tangavius Lesson, Rev. Zool., Feb. 1839, 41.

Type and only species *Tangavius* (= *Callothrus* Cass., 1866) *involucratus* sp. nov. = *Molothrus æneus robustus* Cab. 1851.

Replaces *Callothrus* Cass. 1866, by priority. (*Cf.* Nelson, Proc. Biol. Soc. Wash., XVIII, 1905, p. 125.)

Genus **Xanthocephalus.**

Xanthocephalus Bonaparte, Consp. Av., I, 1850, 431.

Monotypic, with *X. perspicillatus* (Licht.) = *Icterus xanthocephalus* Bonap. as type; hence tautonymic.

Genus **Agelaius.**

Agelaius Vieillot, Analyse, 1816, 33.
3 species = "3 sections."

1. "Troupiale commandeur, Buff." = *Oriolus phœniceus* L.
2. "—— de cayenne, Buff." = *Oriolus guianensis* L., type of *Leistes* Swains. 1826.
3. "—— de cap. More, Buff." = *Oriolus cucullatus* P. L. S. Müll., type of *Hyphantornis* Gray, 1849.

Type, as designated by Gray (1840) and by elimination, *Oriolus phœniceus* Linn., the first species, = the first 'section' of the genus.

Genus **Sturnella.**

Sturnella Vieillot, Analyse, 1816, 34.

Monotypic, with "Stourne, ou Merle à fer-à-cheval, Buff." = *Alauda magna* Linn., 1758, as type.

Genus **Icterus.**

Icterus Brisson, Orn., II, 1760, 85.

Type, by tautonomy and as designated by Gray (1840), [*Icterus*] *icterus* Briss. = *Oriolus icterus* Linn.

Subgenus **Pendulinus.**

Pendulinus Vieillot, Analyse, 1816, 33.

2 noncongeneric species.

1. "*Oriolus spurius (femina).*"
2. "——*ferrugineus* Gm.," type of *Scolecophagus* Swains. 1831 (1832); preoccupied = *Euphagus* Cass. 1866.

Used in the same year, in another connection (Nouv. Dict. d'Hist. Nat., nouv. éd., V, 1816, pp. 315–322), in a much broader sense.

Type, by elimination, *Oriolus spurius* Linn., the first species. (Not *Oriolus banana* Linn., as given by Gray, 1855.)

Subgenus **Yphantes.**

Yphantes Vieillot, Analyse, 1816, 33; Nouv. Dict. d'Hist. Nat., nouv. éd., III, 1816, pp. 214–216.

2 species.

1. "Baltimore franc, Buff." = *Oriolus baltimore* Linn.
2. "*Spurius* (mas.), Gm. Lath."= *Oriolus spurius* Linn., type of *Pendulinus* Vieill. (in next paragraph above on same page).

In the second place of publication, these same two species, and no others, are included.

Type, as designated by Gray (1855) and by elimination, *Oriolus baltimore* Linn. 1766 = *Coracias galbula* Linn. 1758, the first species.

Genus **Euphagus.**

Euphagus Cassin, Proc. Acad. Nat. Sci. Phila., 1866, 413.

Monotypic, with *Psarocolius cyanocephalus* Wagler as type.

Genus **Quiscalus.**

Quiscalus Vieillot, Analyse, 1816, 36.

2 noncongeneric species.

"*Gracula quiscala* et *Corvus mexicanus*, Lin. Gm. Lath.," the latter a species of true *Corvus* Linn. 1758.

Type, by tautonomy, as designated by Gray (1840), and by elimination, *Gracula quiscala* Linn., the first species.

Genus **Megaquiscalus.**

Megaquiscalus Cassin, Proc. Acad. Nat. Sci. Phila., 1866, 409.

6 nominal species, all congeneric, four of them being subspecies of the first species.

1. *major,*
2. *assimilis,*
3. *macrourus,*
4. *tenuirostris,*
5. *palustris,*
6. *peruvianus.*

Nos. 2, 3, 5, and 6 are subspecies of No. 1.

Type, as designated by Sclater (1886) and by common consent, *Quiscalus major* Vieill., the first species.

Family FRINGILLIDÆ.

Genus **Hesperiphona.**

Hesperiphona Bonaparte, Comp. Rend., XXXI, 1850, 424.

Monotypic; "pour la *Fringilla vespertina* de l' Amérique septentrionale" = *Fringilla vespertina* Cooper.

Genus **Pinicola.**

Pinicola Vieillot, Ois. d'Amér. Sept. I, 1807, p. iv, pl. i, fig. 13.

Monotypic, with *Pinicola rubra* Vieill. = *Loxia enucleator* Linn. as type.

Genus **Pyrrhula.**

Pyrrhula Brisson, Orn., III, 1760, 308.

Type, by tautonomy, [*Pyrrhula*] *pyrrhula* Briss. = *Fringilla pyrrhula* Linn.

Genus **Carpodacus.**

Carpodacus Kaup, Skizz. Entw.-Gesch. Eur. Thierw., 1829, 161.

2 congeneric species, *erythrina* and *roseus.*

Type, as designated by Gray (1855) and by general consent, *Loxia erythrina* Linn. (*Erythrina* Brehm, of one year earlier date, and containing the same two species, is preoccupied.)

Genus **Passer**.

Passer Brisson, Orn., III, 1760, 71.

Type, as designated by Gray (1840) and by common consent, [*Passer*] *passer domesticus* Briss. = *Fringilla domesticus* Linn.

The genus originally contained 67 species (some of them nominal, others not identifiable), which was later restricted by various early authors to *F. domestica, F. montana,* and other members of this well-defined group, the only synonym of which is *Pyrgita* Cuvier, 1817, founded for *F. domestica* and *F. montana,* but to which various other (mostly noncongeneric) species were referred in a footnote.

Genus **Loxia**.

Loxia Linnæus, Syst. Nat., ed. 10, I, 1758, 171.

32 species, representing 22 or more modern genera, and including 6 species currently considered as unidentifiable.

Type, by restriction, *Loxia curvirostra,* the first species, and the only species of *Loxia* of Brisson, 1760, of Illiger (ex Linn.) 1811, of Vieillot, 1816, of Cuvier, 1817, of Gray, 1840, and of various subsequent writers. By general consent the Crossbills thus constitute the restricted genus *Loxia,* with *L. curvirostra* Linn. as type.

Genus **Leucosticte**.

Leucosticte Swainson, Faun. Bor.-Am., II, 1831 (Feb. 1832), 267 (first mention), 493 (diagnosis, and type designated).

Monotypic, with *Linaria* (*Leucosticte*) *tephrocotis* sp. nov., as type.

Genus **Acanthis**.

Acanthis Bechstein, Orn. Tachenb. Deutschl., 1802, 125.

4 species, representing 3 modern genera.

1. *carduelis,* type of *Carduelis* Brisson, 1760.
2. *spinus,* type of *Spinus* Koch, 1816.
3. *linaria.*
4. *flammea* — same as No. 3.

Type, by elimination, *Fringilla linaria* Linn.

By the first species rule *Acanthis* is a synonym of *Carduelis* Brisson, and another name would be required for the group now called *Acanthis* in the A. O. U. Check-List. *Ægiothus* Cabanis, Mus. Hein., I, 1851, 161, would be available. The type of *Linota* Bonaparte,1838 (*Fringilla cannabina* Linn.) is not congeneric, from the standpoint of the Check-List, with *Fringilla linaria* Linn., and *Linota* is therefore not available in place of *Acanthis.* The same holds true for *Linaria* Bechstein, 1802. (*Cf.* Stone,

Auk, XXIV, April, 1907, p. 199. Stone attributes the genus *Acanthis* to Borkhausen, Deutschl. Fauna, I, 1797, 248, which work I have been unable to see.)

Genus **Astragalinus**.

Astragalinus Cabanis, Mus. Hein., I, 1851, 159.
3 species, all congeneric.

1. *tristis*.
2. *mexicanus* (= *psaltria* Say), type of *Pseudomitris* Cassin, 1865.
3. *columbianus*, subspecies of No. 2.

Type, by elimination, as designated by Gray (1855), and by common consent, *Fringilla tristis* Linn., the first species.

Genus **Spinus**.

Spinus Koch, Bayer. Zool., 1816, xxxviii, 233.
4 species.

1. *carduelis*, type of *Carduelis* Briss. 1760.
2. *linaria*, type of *Acanthis* Bechst. 1803.
3. *citrinella*, type of *Citrinella* Bonap. 1838.
4. *viridis* = *Fringilla spinus* Linn.

Type, by both tautonomy and by elimination, *Fringilla spinus* Linn., the last species.

Genus **Carduelis**.

Carduelis Brisson, Orn., III, 1760, 53.

Type, by tautonomy, [*Carduelis*] *carduelis* Briss. = *Fringilla carduelis* Linn. (North American only as an introduced species.)

Genus **Passerina**.

Passerina Vieillot, Analyse, 1816, 30.
3 noncongeneric species:

1. "Ministre" = *Tanagra cyanea* Linn., type of *Cyanospiza* Baird, 1858.
2. "Ortolan de riz" = *Fringilla oryzivora* Linn., type of *Dolichonyx* Swainson, 1827.
3. "—— de neige" = *Emberiza nivalis* Linn., type of *Plectrophenax* Stejneger, 1882.

Type, by elimination, *Emberiza nivalis* Linn., the last species.

By the first species rule *Cyanospiza* Baird would become a synonym of *Passerina*.

The error Dr. Stejneger made (Proc. U. S. Nat. Mus., 1882, 33) in proposing *Plectrophenax* for the Snowflakes instead of adopting *Passerina* for this group was in throwing out *Passerina* altogether because preoccupied in botany, in accordance with then current usage. It was not till four years later that the A. O. U. Code first established the ruling that "Zoö-

logical nomenclature has no necessary connection with botanical nomenclature, and....use of a name in Botany, therefore, does not prevent its subsequent use in Zoölogy."

Genus **Calcarius.**

Calcarius Bechstein, Tachenb. Vog. Deutschl., 1802, 130.

Monotypic, with *Fringilla lapponica* Linn. as type.

Genus **Rhynchophanes.**

Rhynchophanes Baird, Bds. N. Amer., 1858, 432 (in text).

Monotypic, with *Plectrophanes mccownii* Lawr. as type.

Genus **Poœcetes.**

Poœcetes Baird, Bds. N. Amer., 1858, 447.

Monotypic, with *Fringilla graminea* Gmel. as type.

By the first species rule *Poœcetes* is a synonym of *Zonotrichia* Swains., 1831 (see below under *Zonotrichia*).

Genus **Ammodramus.**

Ammodramus Swainson, Phil. Mag. (2), I, June, 1827, 435; here incidentally mentioned in describing a new species, with a reference to "*Swains. Zool. Journ.* No. 10," where, a few months later, the genus was formally described and the type designated as *Fringilla caudacuta* Wilson = *Oriolus caudacutus* Gmelin.

Ammodramus Swainson, Zool. Journ., III, Aug.–Nov., 1827, 348. Formal diagnosis and type indicated.

Type, as designated by the author, and also by general usage, *Oriolus caudacutus* Gmel.

Type, by first species rule, *Ammodramus bimaculatus* (= *Coturniculus savannarum bimaculatus* auct.), a bird of a different genus. *Coturniculus* of the A. O. U. Check-List would thus become a synonym of *Ammodramus*, and a new name would be required for the present *Ammodramus* group. (*Cf.* Stone, Auk, XXIV, April, 1907, p. 193, who proposes to replace *Ammodramus* with *Passerherbulus* Maynard, 1895.)

Genus **Passerculus.**

Passerculus Bonaparte, Geogr. and Comp. List, 1838, 33.

3 species, belonging to 2 genera.

1. *savanna.*
2. *palustris,* a species of *Melospiza* Baird, 1858.
3. *lincolni,* congeneric with No. 2.

Type, as designated by Gray (1840) and by Baird (1858), *Fringilla savanna* Wilson.

Subgenus **Centronyx**.

Centronyx Baird, Bds. N. Amer., 1858, 440.

Monotypic, with *Emberiza bairdii* Aud. as type.

Genus **Coturniculus**.

Coturniculus Bonaparte, Geogr. and Comp. List, 1838, 32.

2 congeneric species, generally considered as doubtfully separable from *Ammodramus*.

1. *passerina,* 2. *henslowii.*

Type, as designated by Gray (1840), and by general consent, *Fringilla passerina* Wilson.

Genus **Chondestes**.

Chondestes Swainson, Phil. Mag. (2), I, June, 1827, 435.

Monotypic, with *Chondestes strigatus* sp. nov. (= *C. gramacus strigatus*) as type.

Genus **Zonotrichia**.

Zonotrichia Swainson, Faun. Bor.-Am., II, 1831 (Feb. 1832), 254 (first mentioned), 493 (diagnosis and mention of "types").

4 species, only 2 of which are congeneric.

1. *graminea* (pp. xxiv, xxxv 254), type of *Poœcetes* Baird, 1858.
2. *leucophrys.*
3. *pennsylvanica* = *albicollis* Gmel.
4. *melodia,* type of *Melospiza* Baird, 1858.

Nos. 2 and 3 are congeneric; No. 2, *Emberiza leucophrys* Forster, is currently accepted as the type (designated as such by Gray in 1840), although Bonaparte in 1832 (Saggio Distr. Metod. Anim. Vertebr. a sangue fredo, 1832, p. 83) designated the type as *Fringilla pensylvanica* Lath., as follows: "*Zonitrichia,* Sw. (typ. *Fr. pensylvanica,* Lath.)."

By the first species rule *graminea* might be the type, as the author failed to definitely designate a type, in which case a new name would be necessary for the group now known as *Zonotrichia* in the A. O. U. Check-List, and *Poœcetes* would become a synonym. The case, however, is somewhat peculiar. While *graminea* stands as the first species in three places where the species of *Zonotrichia* are given (pp. xxiv, xxxv, 254–257) it is not included as one of the 'types' (p. 493), where *melodia* is included, while *melodia,* on p. 252, is mentioned as a connectant between *Emberiza* and *Zonotrichia,* and in such a way as to imply its reference to the former.

[In this connection, my attention has been called by Mr. Stone to the genus *Hortulanus* Vieillot, proposed by Vieillot, with a number of others,

in 1807 (Ois. Am. Sept., I, 1807, pp. iii and iv, and pl. i), several of which are in current use. They are each illustrated by figures of the bill and front part of the head of one or more species, and are accompanied by brief and sometimes very inadequate diagnoses; they each have, however, one or more species referred to them.

Genus **Hortulanus**.

Hortulanus Vieillot, Ois. Am. Sept., I, 1807, pp. iii and iv and pl. i.
3 noncongeneric species.

1. "No. 3 [referring to the plate]. Bec d'un Ortolan touit, *Hortulanus erythrophtalmus*" (sic), type of *Pipilo* Vieill. 1816.
2. "No. 6. Bec de l'Ortolan à gorge blanche, *Hortulanus albicollis* .... *Fringilla albicollis* Linn. Gm.," a species of *Zonotrichia* Swains. 1831 (Feb. 1832).
3. "No. 14. Bec de l'Ortolan à cou noir, *Hortulanus nigricollis* .... *Fringilla flavicollis*, et d'*Emberiza Americana*" Gmel., type of *Spiza* Bonap. 1824.

Type, by elimination, *Fringilla albicollis* Gmel., the second species; type by first species rule, *Fringilla erythrophthalmus* Linn.

The figure of the bill of *Hortulanus erythrophtalmus* is poor, but not worse than that of several of the other species figured, as *Hortulanus albicollis* and *H. nigricollis*. In these two cases the names cited in the accompanying text ("Explication des figures de la planche première") leave no doubt as to the species intended. In the case of *Hortulanus erythrophtalmus*, the Linnæan equivalent name is not given, but there can be no doubt that *Fringilla erythrophthalma* Linn. is meant, this being the only red-eyed American Fringilline then known. The name 'touit' is definitive, being not only onomatopœic, but Vieillot's vernacular name for his genus *Pipilo* in 1816[1] and 1819[2]; where, in the first case, he cites as type "Pinson aux yeux rouges, Buff.," and in the second case, "*Emberiza erithrophtalma* Lath.," and also Catesby's and Wilson's figures of this species.

That Vieillot did not, apparently, later make use of the name *Hortulanus*, but adopted *Pipilo* for the first of these three species and *Passerina* for the others, is only one of many similar cases in the writings of not only Vieillot, but of Bonaparte, Swainson, and many other authors of the first half of the nineteenth century. It has the same kind of basis as have *Pinicola*, *Piranga*, and just as good a basis as many other names that have long been in current use and universally accepted.

By elimination *Hortulanus* replaces *Zonotrichia*; by the first species rule *Hortulanus* replaces *Pipilo*.[3]

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[1] Analyse, 1816, p. 32.
[2] Nouv. Dict. d'Hist. Nat., nouv. éd., XXXIV, 1819, p. 291.
[3] Gray (1855) in part referred *Hortulanus* Vieill. to *Pipilo* Vieill. and in part to *Euspiza* Bonap.

Genus **Spizella**.

Spizella Bonaparte, Saggio Distr. Met. An. Vert., 1832, 82.

Type, *Fringilla pusilla* Wilson, the only species mentioned.

Genus **Junco**.

Junco Wagler, Isis, 1831, 526.

Monotypic, with *Junco phæonotus* sp. nov. (= *Fringilla cinerea* Swains. 1827, not of Gmelin, 1788) as type.

Genus **Amphispiza**.

Amphispiza Coues, Bds. Northwest, 1874, 234.
2 congeneric species, *bilineata* and *belli*.

Type, as designated by founder, *Emberiza bilineata* Cass.

Genus **Peucæa**.

Peucæa Audubon, Synop., 1839, 112.
2 noncongeneric species.

1. *bachmani*.
2. *lincolni*, a species of *Melospiza* Baird, 1858.

Type, as designated by Gray (1855) and by elimination, *Fringilla bachmani* Aud. (= *P. æstivalis bachmani*), the first species.

Genus **Aimophila**.

Aimophila Swainson, Class. Bds., II, 1837, 287.
2 species.

1. *rufescens*.
2. *superciliosa*, type of *Plagiospiza* Ridgway, 1898.

Type, by elimination, *Pipilo rufescens* Swains., the first species. (Gray (1855) designated the second species as the type.)

Genus **Melospiza**.

Melospiza Baird, Bds. N. Am., 1858, 478.
7 congeneric species.

1. *melodia*,
2. *heermanni*,
3. *gouldi*,
4. *rufina*,
5. *fallax*,
6. *lincolni*,
7. *palustris*, type of subgenus *Helospiza* Baird, 1868.

Nos. 2–5 are subspecies of No. 1.

Type, as designated by author, *Fringilla melodia* Wilson, the first species.

Genus **Passerella**.

Passerella Swainson, Class. Bds., II, 1837, 288.

Monotypic, with *Fringilla iliaca* Merrem as type.

Genus **Arremonops.**

Arremonops Ridgway, Man. N. Am. Bds., 2d ed., 1896, 434, 605.

Monotypic, with *Emberiza rufivirgata* Lawr. as type.

Genus **Oreospiza.**

Oreospiza Ridgway, Man. N. Am. Bds., 2d ed., 1896, 439.

Monotypic, with *Fringilla chlorura* Aud. as type.

Genus **Pipilo.**

Pipilo Vieillot, Analyse, 1816, 32.

Monotypic; type "Pinson aux yeux rouges, Buff." = *Fringilla erythrophthalma* Linn.

By the first species rule *Pipilo* is a synonym of *Hortulanus* Vieillot, 1807, the first species of which is unquestionably *Fringilla erythrophthalma* Linn. (See above, under *Hortulanus*, p. 360.)

Genus **Cardinalis.**

Cardinalis Bonaparte, Proc. Zool. Soc. Lond., 1837, 111.
3 species, 2 congeneric.
1. *virginianus*, 2. *phœniceus.*
3. *sinuatus*, type of *Pyrrhuloxia* Bonap., 1850.

Type, by tautonomy, *Cardinalis virginianus* Bonap. = *Loxia cardinalis* Linn., the first species.

Genus **Pyrrhuloxia.**

Pyrrhuloxia Bonaparte, Consp. Av., 1850, 500.

Monotypic, with *Cardinalis sinuatus* Bonap. as type.

Genus **Zamelodia.**

Zamelodia Coues, Bull. Nutt. Orn. Club, V, 1880, 98.
2 congeneric species: (1) *ludoviciana*, (2) *melanocephala.*

Proposed to replace *Hedymeles* Cab., 1851, with the same species, in the same order (preoccupied = *Habia* Reich., 1850, also preoccupied). As the type of *Habia* Reich. was *melanocephala*, the type of *Zamelodia* should be the same species, *Guiraca melanocephala* Swains.

Genus **Guiraca.**

Guiraca Swainson, Phil. Mag. (2), I, June, 1827, 438; incidental mention in describing a new species, with the reference, "*Swains. Zool. Journ.* No. 10."

Guiraca Swainson, Zool. Journ., III, Aug.–Dec., 1827, 350, formal diagnosis and designation of "typical species," as follows:

1. *cærulea.*
2. *melanocephala,* type of *Habia* Reich. 1850.
3. *ludoviciana,* congeneric with No. 2.

Type, as designated by Gray (1840) and by elimination, *Loxia cærulea* Linn., the first species.

Genus **Cyanospiza.**

Cyanospiza Baird, Bds. N. Amer., 1858, 500.

5 congeneric species.

1. *parellina,*
2. *versicolor,*
3. *ciris,*
4. *cyanea,*
5. *amœna.*

Type, as designated by the author, *Tanagra cyanea* Linn., the fourth species; also tautonymic.

By the first species rule *Cyanospiza* is a synonym of *Passerina* Vieill. 1816. (See above under *Passerina,* p. 357.)

Genus **Sporophila.**

Sporophila Cabanis, Wiegm. Arch. f. Naturg., 1844, i, 291; Tschudi's Fauna Peruana, Aves, 1844–46, 211.

3 congeneric species.

1, *luctuosa;* 2, *telasco* (Less.); 3, *alaudina* (d'Orb. & Lafr.).

Proposed as a substitute for *Spermophila* Swains. (preoccupied), with: "Types, *Pyrrhula falcirostris, cinereola* Temm. pl. col. p. 11"; the first is not positively identifiable, and the second = *hypoleuca* Licht.

Type, either (and preferably) *Fringilla hypoleuca* Licht. (type of *Spermophila*), or *Spermophila luctuosa* Lafr. (type of *Sporophila* by general consent). In the Check-List no type is given.

Genus **Euetheia.**

Euetheia Reichenbach, Av. Syst. Nat., 1850, pl. 79.

Monotypic, with *Fringilla lepida* Linn. as type.

Genus **Tiaris.**

Tiaris Swainson, Phil. Mag. (2), I, June, 1827, 438. Incidental mention in a faunal paper in describing a new species with a cross-reference to "*Swains. in Zool. Journ.* No. 10," for the diagnosis and type of the genus.

Tiaris Swainson, Zool. Journ., III, Aug.–Nov., 1827, 351. Diagnosis and designation of type.

Type, by designation, *Fringilla ornata* Wied. Type, by priority of association, *Tiaris pusillus* Swains. sp. nov.

The type as twice designated by the author (*cf.* Class. Bds., II, 1837, p. 280), and as universally recognized till 1902, is *Fringilla ornata* Wied. In 1902 (*cf.* Richmond, Auk, XIX, Oct. 1905, p. 87), *Tiaris* was brought

forward to replace *Euetheia* Cab. 1850, on the ground of priority. It would seem, however, that the cross-reference (*cf.* Allen, Auk, XXII, Oct. 1905, pp. 400–407) given in the 'Philosophical Magazine' to the 'Zoological Journal' for the diagnosis and the type should be held to establish as the type of *Tiaris* the species designated by the author in a paper previously sent to the 'Zoological Journal,' but sufficiently delayed in publication to give the 'Philosophical Magazine' paper six months' priority.

Any ruling on the case of *Tiaris* is equally applicable to three other genera first published in these two papers, where we have by a chance association with a new generic name a species that is noncongeneric, from the modern point of view, with the type of the genus as designated by the author. These genera are *Xiphorhynchus, Vermivora, Tiaris* and *Ammodramus,* with which is involved the status of three other genera, *Helminthophila, Coturniculus* and *Dendrornis,* or seven in all, affecting the names of about 60 species and subspecies, one half of which are constituents of the A. O. U. Check-List. Up to 1905 (*cf.* Oberholser, Smiths. Misc. Coll., Quart. Issue, III, pp. 59–68, May 13, 1905) these genera (except *Vermivora,* a synonym of *Helmitheros* Raf. 1819) were all supposed to rest on an unassailable basis, having been universally current since they were founded, fifty to seventy-five years ago, the type in each case having been accepted as designated by the author.

In the recently revised (but as yet unpublished) A. O. U. Code, it is provided that the type of a genus may be designated by the founder in any part of the work or paper where the genus is first published. As it has heretofore been customary to consult the intent of the author, and to accept his types even if only inferentially indicated, and always when designated in connection with a formal diagnosis, it would obviously facilitate stability in nomenclature if to the A. O. U. rule — good as far as it goes — the following reasonable additions were made, namely: "*or by the founder at some later date than the first publication, provided that the species selected as the type is one of the originally included species, and has not in the meantime been made the type of any other genus; and, provided further, that in the meantime a type for the original genus has not been designated in due form by some other author.*" That such a provision would work easily and give satisfactory results is capable of demonstration, the case of the above Swainsonian genera being in point, and also the case of *Spiza,* next following, whereby a very serious overturn of long-established names would be prevented. (See also, *antea, Ectopistes,* p. 326, and *Amizilis,* p. 346.)

Genus **Spiza**.

Spiza Bonaparte, Journ. Acad. Nat. Sci. Phila., IV, i, 1824, 45, 46, 56.
7 species, all noncongeneric from the modern standpoint.

1. *americana*, designated by the author, in 1827, as the type of *Spiza*; also as type of *Euspiza* Bonap. 1832.
2. *savanna*, type of *Passerculus* Bonap. 1838.
3. *socialis*, congeneric with type of *Spizella* Bonap. 1832.
4. *passerina*, type of *Coturniculus* Bonap. 1832.
5. *ciris*, congeneric with No. 6.
6. *cyanea*, type of *Cyanospiza* Baird, 1858.
7. *leucophrys*, usually accepted as type of *Zonotrichia* Swains. 1831.

Before any of the species were transferred to other genera the type was fixed by the author as *Emberiza americana* Gmel. (*cf.* Bonaparte, Specchio Comp. della Orn. di Roma e di Filadelfia, 1827, p. 47, footnote; Ridgway, Proc. U. S. Nat. Mus., III, 1880, pp. 3, 4). Hence:

Type, by designation of founder, *Emberiza americana* Gmel., the first species. Later the same species was made by the founder (Saggio Distr. Metod. Anim. Vertebr. a sangue fredo, 1832, p. 83) the type of a new genus *Euspiza*, and *Spiza* was transferred to his group "Spizæ Tanagroideæ!"

Genus **Calamospiza**.

Calamospiza Bonaparte, Geogr. and Comp. List, 1838, 30.

Monotypic, with *Fringilla bicolor* Townsend (not of Linn.) = *C. melanocorys* Stejn. 1885) as type.

Family TANAGRIDÆ.

Genus **Euphonia**.

Euphonia Desmarest, Hist. Nat. Tang., 1805, pl. xix, and accompanying text. 5 species, usually regarded as congeneric.

1. Euphone organiste = *Pipra musica* Gm.
2. " teite = *Fringilla violacea* Linn.
3. " chlorotique = *Tanagra chlorotica* Linn.
4. " negre = *Tanagra cayennensis* Linn.
5. " olive = *Euphonia olivacea* sp. nov.

In 1840, G. R. Gray (List Gen. Bds., 1840, p. 44) designated *Pipra musica* Gmel. as the type of *Euphonia* (= *Euphone* Gray), and this designation was affirmed by Cabanis in 1860 (Journ. f. Orn., 1860, 333), who referred *Cyanophonia* Bonap. (Rev. et Mag. de Zool., 1851, p. 158) to it as a synonym, *Cyanophonia* originally including only *Pipra musica* Gmel. and *Euphonia nigricollis* Vieill., it having been proposed for the blue-headed Euphonias only.

Genus **Piranga**.

Piranga Vieillot, Ois. Am. Sept., I, 1807, p. iv.

Monotypic, with *Piranga rubra* = *Muscicapa rubra* Linn. 1766 = *Fringilla rubra* Linn., 1758, as type.

Family HIRUNDINIDÆ.

Genus **Hirundo**.

Hirundo LINNÆUS, Syst. Nat., ed. 10, 1758, 191.
8 species, nearly all noncongeneric.

1. *rustica*.
2. *esculenta*, type of *Callocalia* Gray, 1840.
3. *urbica*, type of *Chelidon* Boie, 1822.
4. *riparia*, type of *Riparia* Forster, 1817.
5. *apus*, type of *Micropus* Mayer & Wolf, 1810.
6. *subis*, type of *Progne* Boie, 1826.
7. *pelagica*, type of *Chætura* Stephens, 1825.
8. *melba*, congeneric with No. 5.

Type, as designated by Gray (1840) and by elimination, *Hirundo rustica* Linn.

Genus **Progne**.

Progne BOIE, Isis, 1826, 972.

Monotypic, with *Hirundo purpurea* Wilson = *Hirundo subis* Linn. as type.

Genus **Petrochelidon**.

Petrochelidon CABANIS, Mus. Hein., I, 1850, 47.
5 species, now referred to two genera.

1. *melanogastra* Swains.
2. *nigricans* Vieill., type of *Hylochelidon* Gould, 1865; retained in *Petrochelidon* by Sharpe.
3. *leucoptera* Gm. = *albiventris* Bodd., currently referred to *Tachycineta*.
4. *leucorhoa* Vieill., currently referred to *Tachycineta*.
5. *leucopyga* Meyer (nec Licht.) = *meyeni* Cab., currently referred to *Tachycineta*.

Type, as designated by Gray (1855) and by elimination, *Hirundo melanogaster* Swains.

Genus **Tachycineta**.

Tachycineta CABANIS, Mus. Hein., I, 1850, 48.
2 species.

1. *thalassina*.
2. *bicolor*, type of *Iridoprocne* Coues, 1878.

Evidently *Hirundo thalassina* Swains., the only species given in the text (*bicolor* is mentioned in a footnote) was intended as the type, as designated by Gray (1855), and as it is by elimination.

Genus **Iridoprocne**.

Iridoprocne COUES, Bds. Col. Vall., 1878, 412.
5 species mentioned as referable to it.

Type, as designated by the author, *Hirundo bicolor* Vieill.

Genus **Callichelidon.**

Callichelidon Baird, Rev. Am. Bds., 1865, 271, 294, 303.
2 congeneric species.

Type, as designated by the author, *Hirundo cyaneoviridis* Bryant.

Genus **Riparia.**

Riparia Forster, Synop. Cat. Brit. Bds., 1817, 17.

Monotypic, with *Riparia europæa* Forst. = *Hirundo riparia* Linn. as type; also tautonymic.

Genus **Stelgidopteryx.**

Stelgidopteryx Baird, Bds. N. Am., 1858, 312.

Monotypic, with *Hirundo serripennis* Aud. as type.

Family AMPELIDÆ.

Genus **Ampelis.**

Ampelis Linnæus, Syst. Nat., ed. 12, I, 1766, 297.
7 species, mostly noncongeneric.

1. *garrulus.*
2. *pompadora,* type of *Xipholema* Gloger, 1842.
3. *carnifex,* type of *Phœnicercus* Swains. 1831.
4. *cotinga,* type of *Cotinga* Brisson, 1760.
5. *maynana,* congeneric with No. 4.
6. *cayana,* congeneric with No. 4.
7. *tersa,* type of *Procnias* Illiger, 1811.

Type, as designated by Gray (1855, not 1840) and by elimination, *Lanius garrulus* Linn., the first species.

Family PTILIOGONATIDÆ.

Genus **Phainopepla.**

Phainopepla Sclater, Proc. Zool. Soc. Lond., 1858 (Jan. 1859), 543.

Monotypic, with *Ptilogonys nitens* Swains. as type.

Family LANIIDÆ.

Genus **Lanius.**

Lanius Linnæus, Syst. Nat., ed. 10, 1758, 93.
10 species, belonging to 6 genera.

1. *cristatus,* type of *Otomela* Bonap. 1854.

2. *excubitor.*
3. *collurio,* type of *Enneoctonus* Boie, 1826.
4. *tyrannus,* type of *Tyrannus* Cuvier, 1799.
5. *carnifex,* type of *Phœnicercus* Swains. 1831.
6. *schach,* congeneric with No. 2.
7. *senator,* congeneric with No. 2.
8. *cœrulescens* = *Buchanga cœrulescens* auct.
9. *jocosus,* a species of *Otocompsa* Cab. 1850.
10. *garrulus,* type of *Ampelis* Linn. 1766.

Nos. 1, 3, and 6 are, by common consent, congeneric with No. 2.

Type, by elimination, as designated by Gray (1840), and by general usage, *Lanius excubitor* Linn., the second species.

Family VIREONIDÆ.

Genus **Vireo.**

Vireo Vieillot, Ois. Am. Sept., I, 1807 (1808), 83.
3 noncongeneric species.

1. *musicus* = *noveboracensis* Gmel.
2. *virescens* = *olivaceus* Linn., type of *Vireosylvia* Baird, 1866, ex Bonap. 1838.
3. *flavifrons,* type of *Lanivireo* Baird, 1866.

Type, as designated by Gray (1840), by elimination, and by general consent, *Muscicapa noveboracensis* Gmel., the first species.

Genus **Vireosylva.**

Vireosylva Bonaparte, Geogr. and Comp. List, 1838, 26.
2 congeneric species, *olivacea* and *bartrami* Sw. = *agilis* Licht.

Type, as designated by Gray (1840), and later by Baird (1866), *Muscicapa olivacea* Linn.

Genus **Lanivireo.**

Lanivireo Baird, Rev. Am. Bds., May, 1866, 345.
4 congeneric species.

Type, as designated by the author, *Vireo flavifrons* Vieill.

Family CŒREBIDÆ.

Genus **Cœreba.**

Cœreba Vieillot, Ois. Am. Sept., I, 1807 (1808), 80.

Monotypic, with *Certhiola flaveola* Linn. as type.

Family MNIOTILTIDÆ.

Genus **Mniotilta.**

Mniotilta Vieillot, Analyse, 1816, 45.

Monotypic, with "Figuier varia, Buff." = *Motacilla varia* Linn., as type.

Genus **Protonotaria.**

Protonotaria Baird, Bds. N. Am., 1858, 239.

Monotypic, with *Motacilla citrea* Bodd. 1783 = *Motacilla protonotaria* Gmel. 1788; hence also tautonymic.

Genus **Helinaia.**

Helinaia Audubon, Synop., 1839, 66.

10 species, representing 4 modern genera.

1. *swainsonii.*
2. *vermivora,* type of *Helmitheros* Rafin. 1819, and of *Vermivora* Swains. 1827.
3. *protonotarius,* type of *Protonotaria* Baird, 1858.
4. *chrysoptera,* congeneric with No. 10.
5. *bachmanii,* " " " "
6. *carbonata* — indeterminable.
7. *peregrina,* congeneric with No. 10.
8. *solitaria,* " " " "
9. *celata,* " " " "
10. *rubricapilla,* type of *Helminthophaga* Cab. 1850.

Nos. 4, 5, 7, 8 and 9 are congeneric with No. 10, *rubricapilla,* the type of *Helminthophaga* Cabanis, 1850.

Type, as designated by Coues (Bds. Col. Vall., 1878, p. 212) and by elimination, *Sylvia swainsonii* Aud., the first species.

Genus **Helmitheros.**

Helmitheros Rafinesque, Journ. de Phys., LXXXVIII, June, 1819, 418.

"Le type de ce genre est la Fauvette vermivore de Wilson, que je nomme *H. migratorius*" = *Sylvia vermivora* Wilson = *Motacilla vermivora* Gmel. Monotypic.

Genus **Helminthophila.**

Helminthophila Ridgway, Bull. Nutt. Orn. Club, VII, Jan. 1882, 53.

8 species, all congeneric, as follows:

1. *bachmanii,*
2. *chrysoptera,*
3. *pinus* L. = *solitaria* Wils.,
4. *ruficapilla,*
5. *virginiæ,*
6. *celata,*
7. *peregrina,*
8. *luciæ.*

Proposed to replace *Helminthophaga* Cabanis, 1850, with *Sylvia rubricapilla* Wilson as type, which thus becomes the type of *Helminthophila.*

[In this connection it is necessary to consider the case of *Vermivora* Swains. (*cf.* Oberholser, Smiths. Misc. Coll., Quart. Issue, III. pt. 1, May 13, 1905, pp. 66, 67).

Vermivora SWAINSON, Phil. Mag. (2), June, 1827, 434, an incidental use of the name with a cross-reference to "*Swains. Zool. Journ.* No. 10."

Vermivora SWAINSON, Zool. Journ., III, Aug.–Nov., 1827, 170; diagnosis and type designated.

Type of *Vermivora*, as designated by the author and by tautonomy, *Sylvia vermivora* Wilson, which renders *Vermivora* a synonym of *Helmitheros* Rafinesque, 1819.]

Genus **Compsothlypis.**

Compsothlypis CABANIS, Mus. Hein., I, 1850, 20.

3 species, 2 of them congeneric.

1. *americana*; 2, *pitiayuma*; 3, *mexicana*.

Nos. 1 and 2 are congeneric; No. 3 was removed by Ridgway in 1884 to his genus *Oreothlypis*.

Type, as indicated by Gray (1855) and by common consent, *Parus americanus* Linn., the first species.

Genus **Peucedramus.**

Peucedramus COUES, Zool. Wheeler's Expl. W. 100th Merid., 1876, 201.

Monotypic, with *Sylvia olivacea* Giraud as type.

Genus **Dendroica.**

Dendroica GRAY, List. Gen. Bds., 1842, App., 8.

Type, as designated by the author, *Sylvia coronata* Lath.; also monotypic.

Genus **Seiurus.**

Seiurus SWAINSON, Phil. Mag. (2), I, May, 1827, 369.

2 species, *aurocapillus* and *tenuirostris*, the latter not satisfactorily identifiable.

Type, by elimination, and also by designation (Swains., Zool. Journ., III, Apr.–July, 1827, 171), *Motacilla aurocapillus* Linn.

Genus **Oporornis.**

Oporornis BAIRD, Bds. N. Am., 1858, 246.

2 species, *agilis* and *formosa*.

"The typical species is quite similar in color to *Geothlypis philadelphia*." Hence, type by indirect designation, *Sylvia agilis* Wils., *formosa* being very differently colored from *G. philadelphia*.

Genus **Geothlypis.**

Geothlypis CABANIS, Wiegm. Arch. f. Naturg., 1847, i, 316.

To replace "*Trichas* Sws. nec Gloger."

Trichas SWAINSON, Zool. Journ., III, Apr.–July, 1827, 167.

Type of *Trichas*, by designation and tautonomy, *Trichas personatus* Swains. = *Turdus trichas* Linn. Hence the type of *Geothlypis* should be *Turdus trichas* Linn.

Subgenus **Chamæthlypis**.

Chamæthlypis Ridgway, Man. N. Am. Bds., 1887, 525.

Type, as designated by the author, *Geothlypis poliocephala* Baird.

Genus **Icteria**.

Icteria Vieillot, Ois. Am. Sept., I, 1807, iv, 85.

Monotypic, with *Icteria dumicola* Vieill. = *Turdus virens* Linn. as type.

Genus **Wilsonia**.

Wilsonia Bonaparte, Geogr. and Comp. List, 1838, 23.
4 species: 3 congeneric, 1 indeterminable.

1. *mitrata.*
2. *bonapartei* = *Musicapa canadensis* Linn., congeneric with No. 1.
3. *minuta*, indeterminable.
4. *pusilla*, congeneric with No. 1.

Type, as designated by A. O. U. Committee in 1899 (Auk, XVI, p. 123), *Motacilla mitrata* Gmel., the first species.

Genus **Setophaga**.

Setophaga Swainson, Phil. Mag. (2), May, 1827, 368, with cross-reference to "*Swains. Zool. Journ.* No. 10." (= Zool. Journ., III, July–Nov., 1827, 368), where diagnosis is first given and type designated.

Monotypic, with type designated as *Muscicapa ruticilla* Linn.

In the original place of publication (Phil. Journ., *l. c.*) *Setophaga* contained 3 species, as follows:

1. *ruticilla.*
2. *miniata*, removed by Baird, 1865, to his genus *Myioborus.*
3. *rubra*, type of *Ergaticus* Baird, 1865.

The type, by elimination, is also *Motacilla ruticilla* Linn., the first species.

Genus **Cardellina**.

"*Cardellina* Du Bus, Esq. Orn., 1850, pl. 25." (Not seen.)

Monotypic, with *Cardellina amicta* Du Bus = *Muscicapa rubrifrons* Giraud.

Genus **Ergaticus**.

Ergaticus Baird, Rev. Am. Bds., 1865, 237, 264.

Monotypic, with *Setophaga rubra* Swains. as type.

Genus **Basileuterus.**

Basileuterus Cabanis, Schomburgk's Reise in Guiana, III, 1848, 666.

Monotypic, with *B. vermivorus* (Cab.) = *Sylvia vermivora* Vieill. as type.

Family MOTACILLIDÆ.

Genus **Motacilla.**

Motacilla Linnæus, Syst. Nat., ed. 10, 1758, 184.
34 species, representing numerous modern genera.

Type, as designated by Gray (1840) and by universal consent, *M. alba* Linn., the tenth species.

The type by an unrestricted first species rule would be *M. lucinia* Linn. = *Ædon luscinia* auct., or more properly *Luscinia luscinia*, and the very large group now known as *Motacilla* would require a new name.

Genus **Budytes.**

Budytes Cuvier, Règne Anim., I, 1817, 371.

Monotypic, with *Motacilla flava* Linn. as type.

Genus **Anthus.**

Anthus Bechstein, Gem. Naturg. Deutschl., III, 1807, 704.
4 congeneric species, forming two unnamed "families" or subgenera.

1st fam.

1. "*Anthus arboreus* mihi = *Alauda trivialis* Gm. L.," type of *Spipola* Leach, 1816, and of *Pipastes* Kaup, 1829.
2. "*Anthus campestris* mihi = *Alauda pratensis* = *campestris* ? Gm. L. No. 4," type of *Agrodoma* Swains. 1837.

2d fam.

3. "*Anthus pratensis* mihi = *Alauda pratensis* Gm. L. No. 2," type of *Leimoniptila* Kaup, 1829.
4. "*Anthus aquaticus* mihi = *Alauda spinoletta* L. 12 ed. p. 288."

Type, as designated by Gray in 1840, and by general consent, *Anthus arboreus* Bechst. = *Alauda trivialis* Linn., the first species; type by elimination, and as given in the Check-List, *Anthus aquaticus* Bechst. = *Alauda spinoletta* Linn., the fourth species. As the four original species of *Anthus* are now universally treated as congeneric, there seems to be no objection to taking as the type the species designated by Gray in 1840.

Family CINCLIDÆ.

Genus **Cinclus.**

"*Cinclus* Borckhausen, Deutchl. Fauna, I, 1797, 300." (Not seen.)

Type, by tautonomy, *Sturnus cinclus* Linn.

Family MIMIDÆ.

Genus **Oroscoptes.**

Oroscoptes Baird, Bds. N. Am., 1858, 346.

Monotypic, with *Orpheus montanus* Townsend as type.

Genus **Mimus.**

Mimus Boie, Isis, 1826, 972.

Monotypic, with *Turdus polyglottos* Linn. as type.

Genus **Galeoscoptes.**

Galeoscoptes Cabanis, Mus. Hein., I, 1850, 82.

Monotypic (in the text, two other species referred to it in a footnote), with *Muscicapa carolinensis* Linn. as type. Antedated by *Spodesilaura* Reichenbach, 1850, with same type. Mr. Stone (*cf.* Auk, XXIV, April, 1907, p. 193) claims a still earlier name with which to replace *Galeoscoptes*, namely, *Dumetella* "S. D. W." 1837 (an unknown author), based on the "Cat Thrush of Latham" = ? Cat Thrush of Wilson.

Genus **Toxostoma.**

Toxostoma Wagler, Isis, 1831, 528.

Monotypic, with *T. vetula* Wagler = *Orpheus curvirostris* Swains. as type.

Subgenus **Harporhynchus.**

Harporhynchus Cabanis, Wiegm. Arch. f. Naturg., 1848, i, 98.

Type, as designated by author, *Harpes rediviva* Gambel. To replace *Harpes*, preoccupied in carcinology (Goldfuss, 1839).

Family TROGLODYTIDÆ.

Genus **Heleodytes.**

Heleodytes Cabanis, Mus. Hein., I, 1850, 80.
2 congeneric species, *grisea* Swains., and *minor* sp. nov.

Type, as designated by Gray (1855) and by common consent, *Furnarius griseus* Swains.

Genus **Salpinctes.**

Salpinctes Cabanis, Wiegm. Arch. f. Naturg., 1847, i, 323.
2 species, *obsoletus* Say and *mexicanus* Swains.

The latter became the type of *Catherpes* Baird, 1858, leaving *Troglodytes obsoletus* Say as type of *Salpinctes*, as designated by Gray (1855).

Genus **Catherpes.**

Catherpes Baird, Bds. N. Am., 1858, 356.

Monotypic, with *Thryothorus mexicanus* Swains. as type.

Genus **Thryothorus.**

Thryothorus Vieillot, Analyse, 1816, 45, 70.

Monotypic, with "Troglodyte des roseaux, Vieill. Ois. Am. Sept." = *Troglodytes arundinaceus* Vieill., *l. c.*, a composite species.

Type, as first correctly determined by Baird (1858), *Sylvia ludoviciana* Latham.

Troglodytes arundinaceus Vieill. is composite, the plate and description (both poor) evidently indicating the Carolina Wren (*Sylvia ludoviciana* Lath.) while the very full account of the bird's haunts, habits, and particularly the manner of nesting, belong exclusively to the Long-billed Marsh Wren = *Certhia palustris* Wilson, as later stated by Vieillot himself (Nouv. Dict. d'Hist. Nat., nouv. éd., XXXIV, 1819, p. 58), who says the bird figured in his 'Oiseaux de l'Amérique septentrionale' is the Carolina Wren, while the whole account of its habits belongs to the Marsh Wren.

Genus **Thryomanes.**

Thryomanes Sclater, Cat. Am. Bds., 1862, 22.

Monotypic, with *Troglodytes bewickii* Aud. as type.

Genus **Troglodytes.**

Troglodytes Vieillot, Ois. Am. Sept., II, 1807 (1808 or later), 52.

2 noncongeneric species.

1. *aëdon.*
2. *arundinacea,* type of *Thryothorus* Vieill. 1816.

Type, by elimination, *Troglodytes aëdon* Vieill., the first species.

Evidently Vieillot's name is tautonymic, from *Motacilla troglodytes* Linn., but as originally founded it contained only the two species above mentioned. Later, in 1816 (Analyse, p. 44), he stated that it contained "2 sections" and gave, "*Esp.* Troglodyte, Buff. — *Trog. œdon* Vieill. Ois. de l'Am." The first species (= first section) is, of course, the *Motacilla troglodytes* Linn. At this time he eliminated the second species, *Troglodytes arundinaceus* (composite), included in it in 1808, making it the only species of his new genus *Thryothorus.* In 1819 (Nouv. Dict. d'Hist. Nat., nouv. éd., XXXIV, pp. 505–575) he maintained this separation, but added to *Troglodytes* the Winter Wren, various species of South American wrens allied to the House Wren, and also the European Wren. As, however,

the type of the genus *Troglodytes* must be one of its originally included species, the type is necessarily *Troglodytes aëdon* Vieill.

Genus **Olbiorchilus**.

Olbiorchilus Oberholser, Auk, XIX, 1902, 177.

Type, by designation, *Motacilla troglodytes* Linn. Proposed to replace *Anorthura* auct., not of Rennie, which, as given by Rennie, is merely a substitute name for *Troglodytes* Vieill. *Olbiorchilus*, however, it is claimed, must be replaced by the much earlier, but only recently discovered genus *Nannus* Bilberg, 1828, with the same type, given to replace *Troglodites* Cuvier, 1817, not of Vieillot, 1808. (*Cf.* Stone, Auk, XXIV, April, 1907, p. 194.)

Genus **Cistothorus**.

Cistothorus Cabanis, Mus. Hein., I, 1850, 17.

Monotypic, with *C. stellaris* = *Troglodytes stellaris* Licht. as type.

Genus **Telmatodytes**.

Telmatodytes Cabanis, Mus. Hein., pt. i, 1850, 78.
2 noncongeneric species.

1. *arundinaceus* (= "*Thryoth. arundinaceus* Vieill., *Certhia palustris* Wils.").
2. *bewickii* (= *Troglodytes bewicki* Aud.), type of *Thryomanes* Sclat. 1861.

Type, by elimination, *Certhia palustris* Wils., the first species.

Thryothorus arundinaceus Vieill. being composite, as already explained, the type is necessarily *Certhia palustris* Wils., cited by Cabanis as a synonym of Vieillot's species, and thus indicating the species really intended.

Family CERTHIIDÆ.

Genus **Certhia**.

Certhia Linnæus, Syst. Nat., ed. 10, 1758, 118.
5 species, of which 2 are unidentifiable.

1. *familiaris*.
2. *pusilla*, not identifiable.
3. *cærulea*, a species of *Cyanerpes* Oberholser, 1899 = *Cœreba* auct., not Vieillot.
4. *cruentata*, not identifiable.
5. *flaveola*, type of *Cœreba* Vieill. 1807 = *Certhiola* Sundevall, 1835.

Type, as designated by Gray (1840) and by elimination, *Certhia familiaris* Linn., the first species.

Family SITTIDÆ.

Genus **Sitta**.

Sitta Linnæus, Syst. Nat., ed. 10, 1758, 115.

Monotypic, with *Sitta europæa* Linn. as type.

Family PARIDÆ.

Genus **Bæolophus**.

Bœolophus Cabanis, Mus. Hein., 1850, 91.

Monotypic, with *Parus bicolor* Linn. as type.

Genus **Parus**.

Parus Linnæus, Syst. Nat., ed. 10, I, 1758, 189.
12 species, representing 8 modern genera and 2 families.

1. *cristatus*, type of *Lophophanes* Kaup, 1829.
2. *major*.
3. *americanus*, type of *Compsothlypis* Cab. 1850.
4. *cæruleus*, type of *Cyanistes* Kaup, 1829.
5. *ater*, type of *Pœcile* Kaup, 1829.
6. *palustris*, congeneric with No. 5.
7. *caudatus*, type of *Acredula* Koch, 1816.
8. *biarmicus*, type of *Panurus* Koch, 1816.
9. *pipra* = *Pipra leucocilla* Linn., 1766, type of *Pipra* Linn. 1766, by tautonomy.
10. *erythrocephalus* = *Pipra erythrocephala* Linn. 1766, congeneric with No. 9.
11. *aureola* = *Pipra aureola* Linn. 1766, congeneric with No. 9.
12. *cela* = *Oriolus persicus* Linn. 1766, a species of *Cacicus* (*cf.* Hartert, Nov. Zool., XIII, 1906, p. 20).

Type, as designated by Gray (1840) and by elimination, *Parus major* Linn., the second species. By the first species rule *Lophophanes* becomes *Parus* and a new name would be required for the group currently designated as *Parus*.

[By a recent but as yet unpublished ruling of the A. O. U. Committee *Penthestes* takes the place of *Parus* in the A. O. U. Check-List; hence:

Genus **Penthestes**.

Penthestes Reichenbach, Av. Syst. Nat. Trepid., 1850, pl. 62.

Monotypic, with *Parus lugubris* Temm., as type, with which the American species referred to *Parus* in the A. O. U. Check-List are congeneric.]

Genus **Psaltriparus**.

Psaltriparus Bonaparte, Compt. Rend., XXXI, 1850, 478.

Monotypic, with *Psaltriparus personatus* sp. nov. = *Parus melanotis* Hartlaub, 1844, as type.

Genus **Auriparus**.

Auriparus Baird, Rev. Am. Bds., 1864, 85.

Monotypic, with *Ægithalus flaviceps* Sund. as type.

Family CHAMÆIDÆ.

Genus **Chamæa**.

Chamæa Gambel, Proc. Acad. Nat. Sci. Phila., 1847, 154.

Monotypic, with *Parus fasciatus* Gamb. as type.

Family SYLVIIDÆ.

Genus **Acanthopneuste**.

Acanthopneuste Blasius, Naumannia, 1858, 313.

Type, by implication, *Phyllopneuste* [*Acanthopneuste*] *borealis* sp. nov. Includes also *Phyllopneuste javanica* (Horsfield), which is congeneric.

Genus **Regulus**.

Regulus Cuvier, Leç. d'Anat. comp., I, 1799, tab. ii.

Monotypic, with the "Roitelet" = *Motacilla regulus* Linn. as type; hence also tautonymic.

Genus **Polioptila**.

Polioptila Sclater, Proc. Zool. Soc. Lond., 1855, 11.
4 species, all congeneric.

Type, by implication, and as designated by Gray (1855), and also by universal consent, *Motacilla cærulea* Linn.

Family TURDIDÆ.

Genus **Myadestes**.

Myadestes Swainson, Jardine's Nat. Libr., XIII, Flycatchers, 1838, 132.
Monotypic, with *Myadestes* [sic] *genibarbis* sp. nov. as type.

Genus **Hylocichla**.

Hylocichla Baird, Rev. Am. Bds., 1864, 12.

Type, by designation, *Turdus mustelinus* Gmel.

Genus **Turdus**.

Turdus Linnæus, Syst. Nat., ed. 10, I, 1758, 168.
16 species, representing 13 modern genera or subgenera.

1. *viscivorus*.
2. *pilaris*, type of *Arceuthornis* Kaup, 1829.
3. *iliacus*, type of *Iliacus* Des Murs, 1860.
4. *musicus*, congeneric with No. 1.
5. *canorus*, type of *Crateropus* Swains. 1831.
6. *rufus*, a species of *Toxostoma* Wagler, 1831.
7. *polyglottus*, type of *Mimus* Boie, 1826.
8. *orpheus*, congeneric with No. 7.
9. *plumbeus*, type of *Mimocichla* Scl. 1859.
10. *crinitus* = *Muscicapa crinita* Linn. 1776, a species of *Myiarchus* Cab. 1845.
11. *roseus*, type of *Merula* Koch, 1816.
12. *merula*, type of *Merula* Leach, 1816, not of Koch, 1816.
13. *torquatus*, type of *Copsichus* Kaup, 1829; congeneric with No. 1.
14. *solitarius* = *Turdus cyanus* Linn. 1766, a species of *Monticola* Boie, 1822; also type of *Cyanocincla* Hume, 1873.
15. *arundinaceus*, type of *Acrocephalus* Naum. 1811.
16. *virens*, type of *Icteria* Vieill. 1807.

Nos. 1, 4, and 13 are commonly regarded as congeneric.

Type, as designated by Gray (1840), and by general consent, *Turdus viscivorus* Linn., the first species.

Genus **Planesticus**.

Planesticus Bonaparte, Compt. Rend., XXXVIII, Jan. 1854, 3.
6 species.

Turdus lereboulleti sp. nov. = *Turdus jamaicensis* Gmel.

1. *Planesticus albiventer* Bp.
2. *Turdus amaurochalinus* Cab.
3. " *phœopygus* Cab.
4. " *assimilis* Cab.
5. " *tristis* Cab.

Various other species are mentioned as belonging to it.

Type, as selected by Baird (1864) and since generally accepted, *Turdus jamaicensis* Gmel.

To replace *Merula* Leach, recently discovered to be preoccupied by *Merula* Koch (1816), with *Turdus roseus* Linn. as type and only species. (*Cf.* Stone, Auk, XXIV, April, 1907, p. 194.)

Genus **Ixoreus**.

Ixoreus Bonaparte, Compt. Rend., XXXVIII, Jan. 1854, 3 (footnote).

Monotypic, with type by designation, *Turdus nævius* Gmel.

Genus **Cyanecula**.

Cyanecula Brehm, Isis, Dec., 1828, 1280.
5 congeneric species, only 2 valid.

1. *Cyanecula suecica* Brehm = *cærulecula* Pall.
2. " *orientalis* Brehm, same as No. 1.
3. " *wolfi* Brehm = *cyanecula* Wolf.
4. " *obscura* Brehm, same as No. 3.
5. " *leucocyanea* Brehm, same as No. 3.

Type, by tautonomy, *Sylvia cyanecula* Wolf.

Cyanecula is preoccupied by *Cyanosylvia* Brehm on an earlier page in the same paper, and based exclusively on *Sylvia suecica* (Linn.). (*Cf.* Stone, Auk, XXIV, April, 1907, 193.)

Genus **Saxicola**.

Saxicola Bechstein, Orn. Tachenb., 1803, 216.
3 species, representing 2 genera.

1. *Saxicola œnanthe* = *Motacilla œnanthe* Linn.
2. *Saxicola rubetra* = *M. rubetra* Linn., type of *Pratincola* Koch, 1816.
3. *Saxicola rubicola* = *M. rubicola* Linn., congeneric with No. 2.

Type, as designated by Gray (1840) and by elimination, *Motacilla œnanthe* Linn., the first species.

Genus **Sialia**.

Sialia Swainson, Phil. Mag. (2), I, May, 1827, 369, incidentally employed, with cross-reference to "*Swains. in Zool. Journ*, No. 10."

Sialia Swainson, Zool. Journ., III, July–Nov., 1827, 173, where the genus was first characterized and the type designated as *Motacilla sialis* Linn.

The species first referred to *Sialia* (in Phil. Mag., *l. c.*) is *Sialia azurea*, a *nomen nudum* and of doubtful application.

Type, by designation, *Motacilla sialis* Linn.; also tautonymic.

III. GENERAL SUMMARY.

1. Statistical Résumé.

The Check-List, with its Supplements, comprises 375 genera and 40 subgenera, or a total of 415 generic and subgeneric groups. In addition to these, about 15 other genera are collaterally treated in the foregoing pages. They may be classified as

Monotypic	212
Polytypic	218
	430

The polytypic genera, or those containing two or more species when founded, may be further classified, on the basis of the manner of type determination, as follows:

Type by designation of the author[1]	32
Type by tautonomy[2]	57
Type by elimination (including work of 'first reviser')	124
Type by general consent	5
	218

Of the 124 genera the types of which have been determined by elimination, 34 consisted originally of only congeneric species, and the type has been designated by a 'first reviser' — usually by G. R. Gray, but sometimes, as in the case of genera proposed since 1855, by some later author. The so-called class of 'types by consensus of opinion,' rests either upon elimination — even those of the Linnæan genera — or upon the initiative of some first reviser.

Now that the foregoing pages are in type and can be more readily analysed than when in manuscript, it seems worth while to amplify the remarks on an earlier page (p. 286) in reference to G. R. Gray's work in designating types, and also on the frequency of the first species being the type (as now currently recognized) under the combined operation of the first reviser and elimination, as these two agencies have worked in unison and are inseparable. Of the 124 genera classified above as 'type by elimination,' Gray (1840–1855) indicated types for 90 of them, the first species being the type in 65 cases, and some other than the first species in the other 25, although in 9 of these latter the first species was available as the type at the time he assigned a type. Of the 65 genera for which he took the first species as the type, the first species was the only one available for a type in 30 cases, all the other original species having previously been made the types of other genera, or were strictly congeneric with such types; in 24 other cases either all of the original species were congeneric, or all of those left in the genus at the time he selected a type were congeneric, giving him free rein to select the first species as type without in any way doing violence to the original author's intentions.[3]

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[1] In other words, genera *depending* for their types on designation by the author, but not including all of the genera having types so designated. For convenience of classification, all monotypic genera are placed together as one group, although, as a matter of fact, the type in many cases was also designated by the author, while in 12 cases monotypic genera are also tautonymic, and in a few cases a genus with the type designated by the author is both tautonymic and monotypic.

[2] That is, the type depends entirely on tautonomy; genera that are both tautonymic and monotypic are placed under 'monotypic', as explained in the preceding footnote.

[3] In a few instances, by inadvertence or otherwise, Gray designated as types species not originally included in the genus, and in such cases his designations are necessarily here ignored.

2. Changes Necessary from the Standpoint of Elimination.

Changes in the present Check-List names of genera and subgenera due to the recent discovery of overlooked or preoccupied or otherwise invalid names, or to the rule of tautonomy, are rigidly excluded from consideration in the present comparative résumé.

1. *Cyclorrhynchus*; becomes *Phaleris*.
2. *Phaleris*; becomes *Alcella*.
3. *Procellaria*; becomes *Thalassidroma*.
4. *Ceophlœus*; becomes *Phlœotomus*.

These changes involve only 5 species of North American birds, and result from three errors of elimination. In one case the error was due, apparently, to a mistake in the identification of a species; in the case of *Ceophlœus* the determination of the type was correct from one point of view, but not from a strict consideration of the entire case.

In this connection it would be unpardonable not to call attention to the excellent work of the subcommittee, Mr. Ridgway and Dr. Stejneger, of the original A. O. U. Committee on Nomenclature, who are wholly resposible for the nomenclature of the original edition of the Check-List, prepared for publication twenty-one years ago, on the basis of the then recently adopted A. O. U. Code. That the work was most thoroughly and intelligently done admits of no question.

At this point a word of comment is pertinent relative to the oft-made assertion [1] that elimination is not only difficult, but can be done in so many ways that no two eliminators agree in their results. As said above, I took up this task of elimination as though it had never been done before, wholly independently of the Check-List, and of any results by previous workers. Yet not only do my results agree almost perfectly with the type determinations of the Check-List, but equally close with those of the various authors concerned in the preparation of the British Museum 'Catalogue of Birds,' so far as the genera are strictly comparable. The coincidence of types by elimination with the type designations of Gray, made half a century ago, has already been noted. In other words, Gray's selection of types must have been, in a great many cases, due to careful elimination, in order to determine which of the original components of a genus were available as the type.

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[1] *Cf.* Science, N. S., Vol. XXIV, 1906, pp. 560–565; Vol. XXV, 1907, pp. 147–151.

3. Changes necessary by strict application of the First Species Rule.

a. Genera.

1. *Aix*; in case *Aix sponsa* is considered noncongeneric with *A. galericulata,* as in Sharpe's 'Hand-List of Birds'; requires a new name.
2. *Actitis*; reduced to synonymy and replaced by *Tringoides.*
3. *Bonasa*; reduced to synonymy and a new name required.
4. *Tympanuchus*; replaced by *Bonasa.*
5. *Cathartes*; replaced by *Rhinogryphus.*
6. *Gypagus*; reduced to synonymy and replaced by *Cathartes.*
7. *Aphelocoma*; reduced to synonymy and replaced by *Cyanurus.*
8. *Acanthis*; reduced to synonymy and replaced by *Ægiothus.*
9. *Passerina*; replaced by *Plectrophenax.*
10. *Cyanospiza*; reduced to synonymy and replaced by *Passerina.*
11. *Poœcetes*; reduced to synonymy and replaced by *Zonotrichia.*
12. *Zonotrichia* (of the Check-List), rendered nameless. (On the *Poœcetes–Zonotrichia* case see *antea,* p. 359.)

b. Subgenera.

13. *Podiceps*; reduced to synonymy and replaced by a new name. (If my view of the case of *Podiceps, antea,* p. 290, be accepted, the name is in any case untenable.)
14. *Dysporus*; reduced to synonymy and rendered nameless (see *antea,* p. 300).
15. *Melanitta*; reduced to synonymy and rendered nameless.

These changes affect the names of 27 species and 15 subspecies; none of these changes is necessary under the rule of elimination. The fortunate rule of tautonomy shifts the burden of change in the cases of a number of other genera from the first species rule to tautonomy; the enforcement of the rule of tautonomy makes them obligatory in any case; without it they would be changed by the first species rule but would remain unchanged by the rule of elimination.

4. Other easily avoidable Changes in the A. O. U. Check-List Names.

Four impending disastrous changes in generic names of North American birds are avoidable by adherence to common sense methods in respect to types by designation of the founder of the genus. As already stated (*antea*, p. 364), four generic names of North American birds were casually associated in their first publication with species not intended as the types of these genera, the paper in which they were intended to have their first publication, with diagnoses and designated types, having been delayed in publication by circumstances beyond the control of the author. These genera are the Swainsonian genera *Ammodramus*, *Coturniculus*, *Tiaris*, and *Vermivora*, which are all liable to be transferred, on a trivial technicality, to associations entirely different from their accepted relations for three-fourths of a century, on the basis of the types as designated by the founder, and hitherto universally accepted. The details having already been given at length in this paper (see *antea*, pp. 358, 363, 364), and a remedy suggested (p. 364), they need not be here repeated. By this proposed overturn:

(1) *Ammodramus* takes the place of *Coturniculus*.

(2) *Coturniculus* is relegated to synonymy and is replaced by a new name.

(3) *Tiaris* takes the place of *Euetheia*, which is reduced to synonymy, and a new name takes the place of the original *Tiaris*.

(4) *Helminthophila* is replaced by *Vermivora*, which is properly a synonym of *Helmitheros*.

This is essentially due to the first species rule, in spirit if not in form, since the first species rule necessarily ignores the function of the first reviser, so influential for stability of nomenclature in the past, even when the first reviser is the founder of the genus. Acceptance of the suggestion already made on p. 364 will prevent such a regrettable overturn of names, involving the nomenclature of 19 species and 12 subspecies of the Check-List and, through the transposition of *Xiphorhynchus* (proposed in the same paper with the other genera mentioned above) and *Dendrornis*, 25 or more exotic species.

As pointedly said by Dr. Stiles[1]: "As a matter of fact, the status of no generic name is satisfactorily established, from the modern point of view, until the type is designated. But when this type is once designated, by any method whatsoever, so long as the species selected was an original species,

[1] Science, N. S., Vol. XXV, 1907, p. 147.

valid from the original author's point of view, and unreservedly classified in his genus, why reopen the question?"

In conclusion, I wish to express my thanks to Mr. Witmer Stone, Curator of Ornithology in the Academy of Natural Sciences of Philadelphia, for his kindness in greatly facilitating my work in the library of the Academy, and for many valued suggestions in connection with the preparation of the present paper; to the library authorities of Columbia University for the loan of books, and to Dr. G. M. Allen, Secretary of the Boston Society of Natural History, for similar courtesies.

59.57.71C:16.5

Article XVII.— NEW SPECIES OF GALL-PRODUCING CECIDOMYIIDÆ.

By William Beutenmüller.

Plates XIII–XVII.

The following notes on some well known and new species of gall-producing Cecidomyiidæ are the results of a few observations made by me on this interesting group of Diptera. In my studies of this family of insects I have endeavored to acquire some knowledge of their galls, larvæ, and food-habits, and not simply to collect the mature insects in the field, because I believe that no attempt should be made to describe the adults only, especially from dried cabinet specimens or specimens collected at random in the field. The adults when dry almost always lose their colors and specimens taken in the field are invariably devoid of certain scales or markings by means of which they may be recognized, making descriptions of them very unsatisfactory. In this respect I agree absolutely with the late Baron R. Osten Sacken who says regarding the study of the Cecidomyiidæ:[1] "It is a peculiarity of the family Cecidomyiidæ that its natural history has always been studied in close connection with its classification. This is owing to the fact that *the gall,* the produce of the insect in its first stage of life, is generally a more striking object in nature than the insect itself. The latter small, tiny, difficult to preserve on account of their extreme delicacy, still more difficult to distinguish from their congeners on account of the uniformity of their appearance and coloring, would afford a very unsatisfactory object of study, unless in connection with the varied deformations which their larvæ produce on plants. The study of this family, different in this respect from most of the other families of insects, cannot be prosecuted apart from the observation of living nature, and for this very reason will always be a monopoly of the naturalist so situated as to afford such observations."

In a recent paper[2] Dr. E. P. Felt loses sight of this important matter and describes one hundred and seventy-nine new species of Cecidomyiidæ of which fifteen only were bred from their galls; the remaining species were taken at random in the field, on flowers, by sweeping or otherwise. He also named ninety-six of his new species after the plants upon which the adults were resting or after those plants in whose vicinity they were found.

[1] Monograph of North American Diptera, Vol. I, 1862, p. 173.
[2] New Species of Cecidomyiidæ, by Ephraim Porter Felt, Albany, New York, 1907, pp. 1–53.

Through the study of their life-history, more than likely it will be found that these species affect entirely different plants from those whose names they now bear. Dr. Felt's paper will undoubtedly cause great confusion. His system of nomenclature is obviously in this case misleading. The student of the subject will naturally conclude that the various species identified by botanical terms appertain to or feed upon the plants whose names have been given to them.

Asphondylia autumnalis sp. nov.

Male and female.— Head black, flattened, front very narrow, somewhat orange; eyes large, deep black. Antennæ long, joints longer than broad, brown. Thorax brown black above, with rather long hairs in the grooves and at the sides. Side of thorax partly dull orange. Abdomen dull orange, densely covered with sepia brown scales obscuring the ground color. Legs brown. Wings hyaline, rather densely covered with brown scales. Cilia sepia brown. Halteres scaled with sepia brown, knob orange. Expanse of male 5.5 mm.; of female 7 mm.

Gall (Plate XIII, Figs. 1, 2).— Globular or irregularly rounded with a number of aborted leaves at the apex, and elations of the stems of the plant at the sides. It is green outside and white inside. Interior rather soft, pithy and somewhat succulent, causing the gall to shrivel up and decay after the flies have emerged. Inside are a number of cells in which the larvæ live. These transform in the gall and the flies emerge during the latter part of August and early in September. The gall measures from 20 to 30 mm. in length and from 15 to 30 mm. in width. It occurs on *Helenium autumnale.*

Habitat.— Valley of the Black Mountains, North Carolina.

The adults were described from seven males and eight females.

Asphondylia patens sp. nov.

Female.— Head black, front orange, posterior edge and neck dull orange. Antennæ dark sepia brown, joints much longer than broad. Thorax dull brown on top, partly dull orange at the sides, and with rather long hairs in the grooves on top and at the sides. Thorax somewhat whitish at the sides if held in a certain light. Abdomen dull orange, densely covered with dark brown hairs and scales. Legs velvety black with a pure white mark on the junction of the femora and tibia; tarsi with a broad white band at the base covering the first three joints; claws white. Wings semiopaque, covered with numerous black scales; costa black with black hairs. Expanse 7 mm. Length 2.75 mm.

Gall (Plate XIII, Figs. 3, 4).— An accumulation of aborted leaves, forming a rosette-like body, measuring from 10 to 20 mm. in length. In the center it is bud-like, and inhabited by a single larva. The gall is formed on the tips of branches of a tall, pale, purple-flowered aster (*Aster patens*) and is caused by the arrest of growth of the terminal buds.

Habitat.— Valley of the Black Mountains, North Carolina.

The adults were described from three females.

The gall is quite common during the latter part of August. The larva pupates in the bud-like chamber and the adult emerges in September.

Asphondylia conspicua *Osten Sacken.*

Asphondylia rudbeckiæ conspicua Osten Sacken, Tr. Am. Ent. Soc., Vol. III, 1870, p. 51; Bergenstamm & Löw, Verh. Zool.-Bot. Gesell. Wien. Vol. XXVI, 1876, p. 69; Beutenmüller, Bull. Am. Mus. Nat. Hist., Vol. IV, 1892, p. 293.

The gall of this species is found on *Rudbeckia triloba* and *Rudbeckia laciniata*. The adult and gall were described by Osten Sacken and the gall is figured here for the first time (Plate XVI, Fig. 6). I have taken it in the valley of the Black Mountains, North Carolina, in August, and have also received it from Miss Alberta Field from Ashtabula, Ohio. The adults emerge late in August and early in September.

Asphondylia globulus *Osten Sacken.*

Asphondylia helianthi globulus Osten Sacken, Tr. Am. Ent. Soc., Vol. II, 1869, p. 301; *ibid.*, Vol. III, 1870, p. 52; Bergenstamm & Löw, Verh. Zool.-Bot. Gesell. Wien, Vol. XXVI, 1876, p. 89; Martin, Psyche, Vol. V, 1888, p. 102.

The gall (Plate XVII, Fig. 16) of this species is found on the giant sunflower (*Helianthus giganteus*) and sawtoothed sunflower (*Helianthus grosse-serratus*) in August and September. The pupa, gall and adult were briefly described by Osten Sacken and again in detail by Martin. The adults emerge in September and October.

Cecidomyia ulmii sp. nov.

Male and female.— Head black. Antennæ rather long, joints about as long as wide, brown. Thorax black on top, red at sides and beneath. Abdomen bright red with a few black scales. Legs brown. Wings hyaline with minute black scales. Cilia brown. Expanse, 2.5 mm.

Gall (Plate XIII, Fig. 5).— This is made by folding and growing together of the small, immature terminal leaves or leaf-buds of the American elm (*Ulmus americana*), causing them to swell into galls.

Habitat.— Bronx, New York City, and vicinity.

Described from three males and fourteen females. The gall may be found during June and July. The imago emerges during the same months.

Cecidomyia nyssæcola sp. nov.

Male and female.— Head jet black. Antennæ as long as the body, joints longer than broad and nearly all of equal size, ciliate, brown. Thorax deep black or deep red with two orange, parallel longitudinal lines along the middle; thorax orange at the sides and beneath. Abdomen orange, sparsely beset with brown scales. Legs dusky brown above, pale sordid white beneath. Wings hyaline with very minute dark scales and with a strong purplish reflection; a broad yellowish transverse band near the base, a large spot below the costa near the middle, another similar spot opposite on the inner margin, and another spot on the outer margin, all yellow. Cilia purplish brown. If held in a certain light the wings are pale yellow, except across the middle, where they are purplish. Expanse about 2.5 mm.

Gall (Plate XIII, Fig. 7). This is made by a narrow upward and inward fold of the margin of the leaf of sour gum (*Nyssa sylvatica*) and measures about .3 to 1 mm. in diameter and from about 2.5 to 3.5 mm. in length. Sometimes only a few of the folds occur on a leaf and again the entire margin on both sides of the leaf is covered with them, causing the leaf to become scalloped. The gall is pale yellowish or yellowish green and contrasts with the dark green leaf, making it a rather conspicuous object, readily detected. The galls are sometimes more or less contiguous when occurring in numbers on the same leaf. When dry the gall becomes brown.

Habitat.— Virginia, Kentucky, Illinois, New York, New Jersey, Pennsylvania, Valley of the Black Mountains, North Carolina, (alt. 3500 feet).

Described from one male and one female.

Very common everywhere in the vicinity of New York, from which locality my specimens were obtained. The gall may be found in June and the fly emerges in July.

Cecidomyia unguicula sp. nov.

Male and female.— Head and antennæ black. Thorax dark brown black with scales of the same color. Thorax dull red at the sides and beneath. Abdomen dark red brown with dark brown scales in form of bands. Legs dark brown. Wings hyaline with dark brown scales, costa dark brown; at the base at the insertion of the wings, blood red. Halteres black. Expanse of male 3 mm.; of female 4 mm.

Gall (Plate XIII, Fig. 9).— Somewhat of the shape of a small carpet-tack with the broad part attached to the leaf. The base is rounded at the sides, from which it suddenly becomes narrow, terminating in a sharp point at the apex. Inside it is hollow and contains a single larva. Found in clusters on the under side of the leaf of hackberry (*Celtis occidentalis*). Length about 3 to 5 mm.; width of base about 2 to 3 mm.

Habitat: Cincinnati, Ohio (Miss Ruth S. Harvey).

Described from two males and eight females.

Cecidomyia rudbeckiæ sp. nov.

Male and female.— Head black, face yellow. Antennæ pale yellowish brown. Thorax pale yellowish brown, dull orange at the side and below. Abdomen bright red. Legs pale yellowish brown. Wings hyaline with pale golden yellow scales in form of patches and bright blue where there are no scales. The blue may be seen only when the insect is held in a certain light. Cilia pale yellow. Halteres pale yellow. Expanse 2.5 to 3 mm.

Gall (Plate XIII, Fig. 6).— This is a deformation and enlargement of the flowerlets of the cone-flower (*Rudbeckia hirta*), sometimes deforming all the flowers in the cone. The enlargements are in form of leaflets which are usually greenish in color or are tinged with brown or reddish.

Habitat.— Valley of the Black Mountains, North Carolina.

Described from two males and five females.

The larva is orange and leaves the flower to pupate in the ground. The fly emerges in August.

Cecidomyia pudibunda *Osten Sacken.*

——,Osten Sacken, Ent. Zeit. Stettin, 1861, p. 419, No. 18 (gall only).

Cecidomyia pudibunda Osten Sacken, Mon. Dipt. N. Am., Vol. I, 1862, p. 202 (gall and larva); Glover, MSS. Notes, Dipt. 1874, p. 9, pl. xii, Fig. 30 (colored figure of gall); Bergenstamm & Low, Verh. Zool.-Bot. Gesell. Wien, Vol. XXVI, 1876, p. 87 (gall only).

Male and female: Head black. Antennæ smoky brown, about as long as the body, ciliate. Thorax, abdomen and legs, semitranslucent, pale yellow. Wings hyaline, with a few dark hairs. Cilia pale yellow. Expanse 2 mm.

Gall (Plate XIII, Fig. 8).— Consists of a fold between the ribs on the leaf of hornbeam (*Carpinus caroliniana*) with the opening on the underside of the leaf. It is usually red above and pale green beneath. In length the galls vary from 4 mm. to the width of the leaf from the midrib to the margin. Usually several or many galls are found upon a single leaf. Formed in June and the larva leaves the gall to pupate on the ground. The adult appears in July. The larva, according to Osten Sacken, is exceedingly small and white; when magnified it appears semi-translucent, with an orange spot about the middle of the body, and with numerous short, erect bristles; the head is distinct, as well as the two short antennæ.

Habitat.— Bronx Park, New York City.

Cecidomyia? chinquapin sp. nov.

Larva.— Orange red. Body elongate with the segments slightly incised at the junctions. Terminal segment with a few very minute filaments. Anchor-process or breast bone (Plate XIV, Fig. 14) narrow at base, gradually increasing in width to the apex, where there are two lateral prongs rounded at the tips. Length 1.75 mm.; width .5 mm.

Gall. (Plate XIV, Figs. 12, 13).— Consists of a small irregular swelling in the burr of chinquapin (*Castania pumila*). It contains a single larva which leaves the gall to pupate in the ground.

Habitat.—Valley of the Black Mountains, North Carolina (W. B.).

The gall may be found during the latter part of September. The adult is unknown.

Cecidomyia? vernoniæ sp. nov.

Larva.— Yellow. Body slender and elongate. Terminal segment rounded without any projections. Anchor-process or breast bone (Plate XV, Fig. 8) long and slender, gradually increasing in width from the base to the apex which has two lateral teeth and a short median one. Length 2.5 mm.; width .5 mm.

Gall (Plate XV, Fig. 7).— Green, sometimes tinged with red, rounded or elongate, and of the texture of the stem of the plant. Inside it is soft, fleshy, and contains a single larva in an elongated, narrow channel. Length about 7 to 12 mm.; width, 5 to 9 mm.

When dry the gall becomes brown and pithy inside and somewhat resembles a cherry-pit. It is usually situated on the mid-rib of the leaf of ironweed (*Vernonia noveboracensis*).

Habitat.— Valley of the Black Mountains, North Carolina (W. B.), Staten Island, New York City (W. T. Davis), Indiana (Mel. T. Cook).

The gall is quite common during September, and the larvæ overwinter and transform in the gall. The adult is unknown.

Cecidomyia? pustuloides sp. nov.

Larva.— Orange. Body somewhat flattened, broad, ovate, with the segments at the sides rounded, and rather deeply incised at the junctions. Terminal segment with two very minute, rather wide-separated projections. Anchor-process or breast bone (Plate XVII, Fig. 2) very narrow from the base to about the middle, from which point it gradually expands, and has two lateral rounded projections at the apex. Length 1.25 mm.; width .8 mm.

Gall (Plate XVII, Fig. 1).— Circular, blister-like, and slightly protruding on each side of the leaf. It measures about 4 to 7 mm. in diameter. Found in clusters on the leaves of different kinds of oaks (*Quercus rubra, Q. coccinea, Q. tinctoria, Q. nana, Q. marylandica*), in September.

Habitat.— Valley of the Black Mountains, North Carolina; Lakehurst, New Jersey.

The adult is unknown.

Cecidomyia? meibomiæ sp. nov.

Larva.— Pale yellow. Body ovate, rather broad. Terminal segment with a deep notch at the middle and without projections. Anal slit deep. Anchor-process or breast bone (Plate XV, Fig. 11), short, slender from the base to the much expanded anterior portion which has two rather long lateral prongs at the apex. Length 1.25 mm.; width .5 mm.

Gall (Plate XV, Figs. 9, 10).— Dull green, subfusiform or elongate-oval, more or less tapering to a long point at the apex, which sometimes show parts of deformed leaves. Inside it is hollow, inhabited by a single larva in a rather large oval chamber at the base of the gall. Beyond this chamber it is lined with whitish fiber to the tip of the gall. It measures from 8 to 22 mm. in length and from 4 to 8 in width. Found during the latter part of August and in September in clusters of three or more at the terminal part of the stem of several species of tick-trefoil (*Meibomia rigida, M. lævigata, M. pauciflora*, etc.).

Habitat.— Valley of the Black Mountains, North Carolina (W. B.); Staten Island, New York City (W. T. Davis).

The adult is unknown.

Cecidomyia? semenivora sp. nov.

Larva.— Orange. Body apparently smooth with the segments incised a little at the junctions. Terminal segment rounded at the tip without any projections or filaments. Anchor-process or breast bone (Plate XV, Fig. 4) rather short, slender, from the base to the much enlarged anterior portion. This part is rounded at the sides with two well separated, large lateral teeth at the apex. Length 2 mm.; width .75 mm.

Gall (Plate XV, Figs. 1, 2).— Green, globular or irregularly rounded with a small nipple at the apex and it is attached by a short stalk to the base of the plant. Inside it is hollow and contains many larvæ (Plate XV, Fig. 3) which feed upon the

deformed seeds. The gall is about the size of a pea or gooseberry and measures from 6 to 14 mm. in diameter.

The gall is a malformation of the seed capsules of apetalous or cleistogamous flowers of stemless or acaulescent violets (*Viola cucullata, V. palmata, V. affinis, V. septentrionalis* and probably other species).

This gall was first recorded by E. L. Green (Pittonia, Vol. V, 1902, p. 103) and described by E. Brainerd (Rhodora, Vol. VI, 1904, p. 15). The specimens from which my descriptions were made were collected by Mr. W. DeW. Miller at Plainfield, New Jersey. According to Mr. Miller, the gall may be found from July until late in October. The larvæ when mature spin cocoons inside the gall and hibernate in this state. The adult is unknown.

Cecidomyia? eupatoriforæ sp. nov.

Larva.— Bright orange red. Body very finely papillose under a high power lens; segments rather deeply incised at the junctions. Terminal segment on the dorsum with a prominent projection notched at the apex. At each side of this projection on the margin of the segment is a pair of very short filaments and a short blunt process; hind angles of segment produced. Anal slit extending across the posterior extremity which is rounded. Anchor-process or breast bone (Plate XVI, Fig. 5) long and slender to the very broad anterior portion, which is rounded at the sides and with two teeth at the apex. Length 3 mm.; width .8 mm.

Gall (Plate XVI, Fig. 4).— Green, succulent and pubescent. Globular or irregularly rounded, with or without a depression at the apex around which are deformed petals of the flowers. It is usually on a short stalk, like the flowers of the plant. Inside it is soft, watery, and is inhabited by several larvæ, which live in separate chambers. Length from about 10 to 16 mm.; width about 8 to 15 mm. The gall grows singly or in clusters among the flower-heads of *Eupatorium ageratoides*, in September.

Habitat: Valley of the Black Mountains, North Carolina (W. B.), Staten Island, New York City (W. T. Davis).

The adult is unknown.

Cecidomyia? verbesinæ sp. nov.

Larva.— Orange red. Body slender, elongate. Terminal segment rounded, without projections. Anchor-process or breast bone (Plate XVI, Fig. 3) long, slender from base to the much enlarged anterior portion which is rounded at the sides and with two blunt lateral prongs at the apex. Length 3 mm.; width 1 mm.

Gall (Plate XVI, Fig. 1).— Bud-like, rounded, terminating in a blunt point at the apex. Sometimes several of the galls are confluent and are then irregular in shape. It is hollow (Plate XVI, Fig. 2) and contains a single larva, which leaves the gall to transform in the ground. When confluent it contains two or three cells. Found on the flower heads of *Verbesina alternifolia* in September.

Habitat.— Valley of the Black Mountains, North Carolina.

The adult is unknown.

Cecidomyia? ramuscula sp. nov.

Larva.— Orange yellow. Body elongate, narrow, with the segments slightly rounded at the sides. Skin minutely papillose under a high power objective. Terminal segment rounded. Anchor-process or breast bone (Plate XVII, Fig. 9), long and of almost equal width to the much dilated anterior portion which has three sharp teeth at the apex and a lateral tooth on each side. Length 3.5 mm.; width .8 mm.

Gall (Plate XVII, Figs. 7, 8).— This is a fusiform swelling on the branches of asters (*Aster dumosus* and *Aster patens*). Inside is an elongate, narrow chamber, inhabited by a single larva, which remains in the gall to pupate. Length 10 to 20 mm.; width 5 to 8 mm.

Habitat.— Valley of the Black Mountains, North Carolina, in September.

The adult is unknown.

Cecidomyia vaccinii *Osten Sacken.*

Cecidomyia sp., Osten Sacken, Ent. Zeit. Stettin, 1861, p. 419, No. 9.

Cecidomyia vaccinii Osten Sacken, Mon. Dipt. N. Am., Vol. I, 1862, p. 196; Glover, MSS. Notes, Dipt., 1874, p. 11; Bergenstamm & Löw, Verh. Zool.-Bot. Gesell. Wien, Vol. XXVI, 1876, p. 91.

Larva.— Orange red. Body somewhat flattened. Segments very slightly incised at the junctions. Terminal segment rounded with a few filaments. Anchor process or breast bone (Plate XVI, Fig. 12) very short, slender to the much enlarged-anterior portion which has two rather prominent lateral prolongations at the apex. Length, 2.75 mm.; width 1 mm.

Gall (Plate XVI, Fig. 10).— Green, cock's comb or oyster-shaped, and fastened to the ribs of the leaf by a hinge and when mature burst open like the valve of a shell. It is hollow inside (Plate XVI, Fig. 11) and contains one or two larvæ which leave the gall to transform in the ground.

Habitat.— Washington, D. C. (Osten Sacken); Valley of the Black Mountains, North Carolina (W. B.).

The gall is found in September and early in October on the underside of the leaves of *Vaccineum stamineum.* The adult is unknown.

Cecidomyia impatientis *Osten Sacken.*

Cecidomyia impatientis Osten Sacken, Mon. Dipt. N. Am., Vol. I, 1862, p. 204; Walsh & Riley, Am. Ent., Vol. II, 1869, p. 63; Beutenmüller, Bull. Am. Mus. Nat. Hist., Vol. IV, 1892, p. 269.

Cecidomyia impatiens Glover, MSS. Notes. Dipt., 1874, p. 8, pl. xi, fig. 16; Bergenstamm & Löw, Verh. Zool.-Bot. Gesell. Wien, Vol. XXVI, 1876, p. 95; Beutenmüller, Am. Mus. Journ., Vol. IV, 1904, p. 116, fig. 65; Ins. Galls Vicin. N. Y., 1904, p. 30, fig. 65.

Baron Osten Sacken described only the gall of this species, as a succulent swelling at the base of the flower of *Impatiens fulva* in September. Walsh and Riley described the gall and larva in detail, with figures of the gall and breast bone (Plate XVI, Fig. 8) of the larva. They also give

Impatiens fulva as the host plant. I have taken the gall at Pine Hill, Catskill Mountains, New York, and in the valley of the Black Mountains, North Carolina, in September, on *Impatiens pallida*. The gall (Plate XVI, Fig. 7) is very succulent and soon decays after the larvæ have escaped from it. The adult is unknown.

Cecidomyia persicoides *Osten Sacken.*

Cecidomyia persicoides Osten Sacken, Mon. Dipt. N. Am., Vol. I, 1862, p. 193; Glover, MSS. Notes, Dipt., 1874, p. 9; Bergenstamm & Löw, Verh. Zool.-Bot. Gesell. Wien, Vol. XXVI, 1876, p. 88; Beutenmüller, Bull. Am. Mus. Nat. Hist., Vol. IV, 1892, p. 267 pl. xiv, fig. 3; Am. Mus. Journ. Vol. IV, 1904, p. 114, fig. 60; Ins. Galls Vicin. N. Y., Vol. IV, 1904, p. 28, fig. 60.

Larva.— White. Body robust, broad with the segments of equal width, except the first and last which are narrower. Terminal segment bluntly rounded at the tip with the anal slit deep and extending across the segment. Anchor-process or breast bone (Plate XVII, Fig. 10) very slender with the anterior portion somewhat broader and lance-shape. Length 4 mm.; width 1.5 mm.

The gall only was described by Osten Sacken and subsequent writers. It is variable in size, round and covered with short down-like hairs. It occurs on the underside of the leaves of different kinds of hickory. The adult is unknown.

Cecidomyia umbellicola *Osten Sacken.*

Cecidomyia sambuci umbellicola Osten Sacken, Tr. Am. Ent. Soc., Vol. III, 1871, p. 52; Glover, MSS. Notes, Dipt., 1874, p. 10; Bergenstamm & Löw, Verh. Zool.-Bot. Gesell. Wien, Vol. XXVI, 1876, p. 91; Beutemüller, Bull. Am. Mus. Nat. Hist., Vol. IV, 1892, p. 269.

The gall (Plate XVI, Fig. 9) of this species was found by Osten Sacken on the red-berried elder (*Sambucus pubens*). I have taken it in June on the common elder (*Sambucus canadensis*). The larva and adult are unknown.

Cecidomyia ? racemicola *Osten Sacken.*

Cecidomyia sp., Osten Sacken, Ent. Zeit. Stettin, 1861, p. 418, No. 11.

Cecidomyia racemicola Osten Sacken, Mon. Dipt. N. Am., Vol. I, 1862, p. 196; Glover, MSS. Notes, Dipt., 1874, pp. 9, 18; Bergenstamm & Löw, Verh. Zool.-Bot. Gesell. Wien, Vol. XXVI, 1876, p. 90.

Rhopalomyia racemicola Felt, New Spec. Cecidom., 1907, p. 24.

Gall (Plate XVII, Fig. 14).— Green, smooth, rounded, tapering to a point at the apex, giving it a bud-like appearance. Inside it is hollow and contains a single larva. Length about 3 mm. and 2.5 mm. in diameter.

Found singly, or in clusters, among the racemes of different kinds of goldenrod (*Solidago canadensis, S. puberula, S. serotina* and probably other species).

Larva.— Bright orange. Body apparently smooth, showing no granulations under the lens. Segments of equal width except the first, second, eleventh and

twelfth, which are narrower. Twelfth segment on the dorsum with two semitransparent rather broad projections, rounded at the tip. Posterior extremity evenly rounded with the anal slit prominent. Anchor-process or breast bone (Plate XVII, Fig. 15) rather long and narrow from the base to the broad anterior portion, which is slightly rounded at the sides, with two rather long, sharp teeth at the apex. Length 2.5 mm.; width .75 mm.

Habitat: Valley of the Black Mountains, North Carolina (W. B.); Staten Island, New York City (W. T. Davis); Washington, D. C. (Osten Sacken).

The galls may be found in September and are somewhat difficult to detect, owing to their resemblance to the buds of the goldenrod flowers. The larvæ leave the gall in autumn and enter the ground to transform. The adults described by E. P. Felt as *Rhopalomyia racemicola* are probably the gall makers of *Cecidomyia racemicola* O. S.

Lasioptera tumifica sp. nov.

Male and female.— Head black, sordid white or yellowish on the posterior edge, face silvery white. Antennæ nearly as long as the thorax, stout, reddish brown, salmon red, or almost black. Thorax black, covered with golden brown hairs forming two parallel lines, composed of erect hairs along the middle; front and sides of thorax to the base of the wings sometimes pale yellow or whitish; at sides deep red with two white spots composed of hairs. Abdomen deep velvety black with a broad white band on the posterior part of each segment. These bands are broken along the dorsum and do not reach the extreme sides of the abdomen. Underside of abdomen with the ground color usually reddish and heavily scaled with silvery white. Legs brown above, paler brown beneath. Wings hyaline with minute blackish scales, costa, black with a white mark a little beyond the middle. This mark is sometimes tinged with red. Cilia brown. Expanse 2.5 to 3.5 mm.

Gall (Plate XIV, Figs. 1, 2).— This is an irregular, rounded, elongate, or kidney-shaped, gnarly, leather-like swelling, usually on one side of the stalk of goldenrod (*Solidago rugosa*). Sometimes it almost or entirely encircles the stem. It is leathery outside and rather soft and pithy inside, containing many orange larvæ. It is found from close to the ground where the roots begin everywhere along the stalk to nearly the middle of the plant, but usually near the lower part. The gall measures from 8 to 24 mm. in length and from 5 to 15 mm. in width.

Larva (Plate XIV, Fig. 3).— Salmon red. Body very broad, ovate. Segments incised at the junctions. Terminal segment evenly rounded and without processes. Anchor-process or breast bone (Plate XIV, Fig. 4), very broad and bulb-like at the base, gradually narrowing to the very broad anterior portion, which is obtusely rounded at the sides and with three rather strong teeth at the tip. Length 3 to 3.5 mm.; width 1 to 1.5 mm.

Habitat.— Bronx Park, and Staten Island, New York City.

Described from ten males and thirty-two females. The larvæ transform in the gall and the adults emerge in May.

Lasioptera cornicola sp. nov.

Male and female.— Head black, front somewhat whitish. Antennæ short,

robust, black. Thorax velvety black with a broad grayish white band anteriorly. Underside black, marked with a little white. Abdomen velvety black with a rather broad white band on the anterior part of the first segment and an indistinct narrow one on the posterior part. A narrow band on each of the second, third and fourth segments posteriorly, remaining segments slightly edged with white scales. These bands do not reach the extreme sides of the body. Underside black with a broad white band along the middle. Anterior legs brown; middle and hind legs with femora and tibiæ at base to the middle brown, remaining parts sordid white; all the tarsi brown. Wings hyaline with black scales, iridescent; costa black with a white mark a little beyond the middle. Halteres white. Expanse 3.75 mm.

Gall (Plate XIV, Figs. 7, 8, 9).— Woody swellings on the twigs, branches or trunks on the dogwood (*Cornus stolonifera*), measuring from about 6 to nearly 150 mm. in length. When situated on the twig, the gall is considerably smaller than those on the larger branches and trunk. It sometimes gnarls the trunk from about one to six inches or more in length. Inside (Plate XIV, Fig. 9) it is hard, woody, with many elongate chambers, each containing a larva.

Larva (Plate XIV, Fig. 10).— Pale yellow. Body very elongate, narrow and slender. Segments one to nine about equal in width; three last segments narrower. Surface of body under a high objective minutely papillose, giving it a granular appearance. Segments at the junctions slightly incised. Terminal segment rounded, finely serrate at the tip, with the anal slit line-like. Head retractile, basal part transversely rugose. Antennæ two-jointed, basal joint short, second joint longer, conical. Anchor-process or breast bone (Plate XIV, Fig. 11) very long, slender, anterior portion broad, slightly sinuate at the sides between the apex and the projecting part from which it gradually narrows to the base. Apex with two rather widely separated, prominent, broad, lateral teeth. Length 3 mm.; width .75 mm.

Habitat. —Bronx Park, and Staten Island, New York City.

Described from five males sixteen females.

The gall is rather common and may be found during all seasons of the year. The larvæ overwinter and pupate in the galls, and the adults emerge during May and June.

Lasioptera asterifoliæ sp. nov.

Male and female.— Head black, whitish behind. Antennæ short, stout, black or red. Thorax deep black with the faint, narrow, parallel lines on the summit composed of golden brown erect hairs in the grooves. Abdomen deep red covered with black scales, posterior segments on each side of the dorsum narrowly edged with white and a row of white dots along each side. Underside of abdomen red. scaled with white. Legs dark brown above, paler beneath. Wings hyaline, finely scaled with black; costa black, with a white mark at the middle. Halteres brown. Expanse 3 to 4 mm.

Gall (Plate XIV, Fig. 15).— Circular, flattened, eye-like blotches on the leaf of a species of aster, measuring about 5 mm. in diameter. Purplish with a sordid whitish centre and margin. Underside dull whitish. Found singly or in numbers, all depending upon the size of the leaf.

Habitat.— Valley of the Black Mountains, North Carolina.

Described from three males and nine females.

The larva pupates within the gall and the fly emerges during the same year in August and early in September.

Lasioptera clavula (*Beutenmüller*).

Cecidomyia clavula Beutenmüller, Bull. Am. Mus. Nat. Hist., Vol. IV, 1892, p. 269, pl. xv, fig. 5; Am. Mus. Journ. Vol. IV, 1904, p. 29, fig. 64; Ins. Galls Vicin. N. Y., 1904, p. 29, fig. 64; Townsend, Proc. Ent. Soc. Wash., Vol. II, 1893, p. 390; Cook, 29th Rep. Dept. Geol. Nat. Hist. Res. Ind., 1904 (1905), p. 840; Proc. Ind. Acad. Sci., 1904, p. 225.

Female.— Head small, black, face whitish. Antennæ short, black. Thorax black with golden brown hairs and a white spot on each side anteriorly. Abdomen brown black above with the segments tipped with white posteriorly. The white being visible only when the insect is held in a certain light. Abdomen beneath yellowish brown covered with white scales. Legs dark brown above, yellowish brown beneath. Wings hyaline, costa narrowly black with a white mark a little beyond the middle. Expanse 3 mm.

Larva.— Bright orange. Body elongate, rather broad. Skin finely papillose under a high lens. Terminal segment with two pointed, hook-like, projections, and two minute filaments at each side. Anchor-process or breast bone (Plate XIV, Fig. 6) short, slender, anterior portion much enlarged with two short lateral teeth. Length 3 mm.; width .75 mm.

Gall (Plate XIV, Fig. 5).— On the terminal twigs of dogwood (*Cornus florida*). It is club-shaped and about ½ to 1 inch long. Inside is an elongate channel inhabited by one or more larvæ.

The larvæ leave the gall in September and October and enter the ground to transform. They overwinter and the adults emerge during May and June.

Lasioptera sambuci (*Felt*).

Cecidomyia sambuci Felt, 21st Rep. Inj. Ins. N. Y., 1905 (1906), p. 131, figs. 46–48.

Female.— Head black, collar white. Antennæ black. Thorax velvety black. Abdomen black above and along the sides, basal segment white and the third and fourth segments each with a white band on the posterior edges. Abdomen broadly white along the middle on the under side. Legs brown. Wings hyaline, costa black with a white mark a little beyond the middle. Cilia brown. Halteres white. Expanse 2.75 to 3 mm.

This species was heretofore known from the larva and gall only, and the adult is here described for the first time. The gall is an irregular gnarly swelling on one side of the stem of the elder (*Sambucus canadensis*). The larvæ overwinter and transform in the gall, and the adults emerge the following May and June. The gall is very common in the vicinity of New York.

Lasioptera nodulosa sp. nov.

Lasioptera farinosa Smith, Bull. N. Agri. Exp. Sta., N. J., 1891, p. 14; 12th Ann. Rep. N. J. Agri. Exp. Sta., 1891 (1892), p. 382, fig. 15; Webster, Bull. 45, Ohio Agricul. Exp. Sta., 1889, p. 188, fig. 14.

Female.— Head black, face sordid white. Antennæ black, basal joints sordid yellowish brown. Thorax deep black, pale whitish brown, in front and on sides to the base of the wings. Collar yellowish brown. Sides of thorax reddish. Abdomen red, covered with blackish brown scales; first segment almost wholly white, and a narrow whitish band on the posterior edges of the following segments. Underside pinkish with white scales. Legs, femora, and tibiæ black with the joints pale brown, tarsi black. Underside of legs pale yellowish brown. Wings hyaline with black scales; costa black with a white mark a little beyond the middle. Halteres reddish. Expanse, 3.5 mm.

Gall (Plate XV, Fig. 5).— Knot-like or gouty, elongate or rounded swelling on the smaller terminal branches of blackberry (*Rubus villosus*). Often there are several galls upon a single twig. Inside there is an elongate chamber inhabited by a single larva. The larva transforms in the gall and the adults emerge in May and June.

Larva.— Orange. Body elongate, narrow, minutely papillose under a high power objective. Terminal segment rounded at the tip with a few spiny processes. Anal slit extending across the segment. Anchor-process or breast bone (Plate XV, Fig. 6) long and narrow to the very broad anterior portion which has two lateral subacute teeth and traces of a very short median one at the middle. Length 2.5 mm.; width .5 mm.

Habitat.— Bronx Park, New York City (W. B.); Ohio (F. M. Webster); New Jersey (J. B. Smith).

Described from twelve females.

The galls and larvæ were described and figured by Professor John B. Smith and F. M. Webster as *Lasioptera farinosa* but they belong to the new species here described. The gall is quite common everywhere in the vicinity of New York City; it somewhat resembles the swellings produced by the larvæ of *Agrilus ruficollis*, which is found on the large stalks of blackberry.

Lasioptera farinosa (*Osten Sacken*).

Cecidomyia farinosa Osten Sacken, Mon. Dipt. N. Am., Vol. I, 1862, p. 204; Glover, MSS. Notes, Diptera, 1874, p. 8; Bergenstamm & Löw, Verh. Zool.-Bot. Gesell. Wien, Vol. XXVI, 1876, p. 96; Beutenmüller, Bull. Am. Mus. Nat. Hist., Vol. IV, 1892, p. 273.

Diplosis farinosa Brodie, Biol. Rev. Ontario, Vol. I, 1894, p. 110.

Female.— Head black, face and mouth parts white. Antennæ stout, short, black. Thorax black above with a broad white border in front to the base of the wings. Abdomen black, posterior edges of the segments white; underside white. Legs pinkish with black scales. Wings hyaline with black scales, costa black with a white mark a little beyond the middle. Expanse, 3.5 mm.

Gall (Plate XV, Fig. 13).— Irregularly rounded and situated on the underside of the midrib or on the petiole at the base of the leaflet of blackberry (*Rubus villosus*).

It is covered with a farinaceous powder and when fresh is rather soft and fleshy, but becomes hard and woody when old. Inside are several cells inhabited by the larvæ. These overwinter in the gall and the adults emerge in May and early June. The gall measures from 6 to 12 mm. in diameter.

Larva.— Orange. Body broad, ovate. Anchor-process (Plate XV, Fig. 12) long and slender, gradually increasing in width to the two lateral teeth at the apex. Length 1–5 mm.; width .5 mm.

Habitat.— New York; New Jersey; Valley of the Black Mountains, North Carolina (W. B); Canada (Brodie).

This species was known heretofore only by the gall described very briefly by Osten Sacken. It is quite common locally in the vicinity of New York City and may be distinguished easily from *Lasioptera nodulosa*, with which it has been confounded by certain writers. *L. farinosa* always occurs on the leaves and petiole of the blackberry while *L. nodulosa* is a gouty swelling on the stems of this plant.

Lasioptera viburnicola sp. nov.

Male and female.— Head black, with the posterior portion, white, palpi white. Antennæ black. Thorax deep black with two not very distinct, median lines composed of white hairs; anterior portion of thorax to the base of the wings broadly white; sides black, scutellum rufous. Abdomen velvety black, first segment wholly white, second, third and fourth segments each with a broad, white, transverse band, on the posterior edges, remaining segments with a few white hairs on the posterior edges. Underside pure white. Legs sordid white, with a broad black band on the femora, and tibiæ; tarsi blackish above. Wings hyaline, with black hairs, costa broadly black, with a conspicuous white mark at the middle. Halteres white. Expanse, 3–3.50 mm.

Larva.— Orange. Body elongate, narrow. Skin finely papillose. Terminal segment rounded at the tip with a few very short setæ. Anchor-process of breast-bone (Plate XVII, Fig. 13) long, narrow from base to the anterior portion which gradually becomes broader. Apex with two rather long, lateral teeth. Length 2.75 mm.; width .66 mm.

Gall (Plate XVII, Figs. 11, 12).— Gnarly, elongate swellings on the larger branches of arrow-wood (*Viburnum dentatum*). It is soft, pithy inside, and the larvæ make long deep channels in the wood of the branch, beneath the pithy portion of the gall. Length 30 to 75 mm.; width 10 to 25 mm.

Habitat.— Bronx, New York City.

The larvæ overwinter and transform in the gall.

Lasioptera? linderæ sp. nov.

Larva.— Whitish with a pale orange tint. Body elongate, narrow, skin very finely papillose. Terminal segment rounded with a few very short setæ. Anal slit extending across the segment. Anchor-process or breast bone (Plate XVII, Fig. 6) narrow, gradually becoming broader at the anterior portion, which has two short lateral teeth at the apex. The teeth are widely separated and are rounded at the tip. Length 2 mm.; width .5 mm.

Gall (Plate XVII, Figs. 3, 4, 5).— Gnarly, elongate, woody swellings, on one side or surrounding the smaller twigs or branches of spicebush (*Lindera benzoin*). It is hard and woody inside with a number of elongate, narrow chambers, in which the larvæ live. Length 15 to 60 mm.; width 7 to 10 mm.

Habitat.— Bronx, New York City.

The larvæ overwinter and transform in the gall. The adult is unknown.

EXPLANATION OF PLATES.

Plate XIII.

Figs. 1 and 2.— *Asphondylia autumnalis* sp. nov.
Figs. 3 and 4.— *Asphondylia patens* sp. nov.
Fig. 5.— *Cecidomyia ulmii* sp. nov.
Fig. 6.— *Cecidomyia rudbeckiæ* sp. nov.
Fig. 7.— *Cecidomyia nyssæcola* sp. nov.
Fig. 8.— *Cecidomyia pudibunda* O. S.
Fig. 9.— *Cecidomyia unguicula* sp. nov.

Plate XIV.

Figs. 1 and 2.— *Lasioptera tumifica* sp. nov.
Fig. 3.— *Lasioptera tumifica*, larva.
Fig. 4.— *Lasioptera tumifica*, anchor-process.
Fig. 5.— *Lasioptera clavula* Beuten.
Fig. 6.— *Lasioptera clavula* anchor-process.
Fig. 7–9.— *Lasioptera cornicola* sp. nov.
Fig. 10.— *Lasioptera cornicola*, larva.
Fig. 11.— *Lasioptera cornicola*, anchor-process.
Fig. 12 and 13.— *Cecidomyia ? chinquapin* sp. nov.
Fig. 14.— *Cecidomyia ? chinquapin*, anchor-process.
Fig. 15.— *Cecidomyia ? asterifoliæ* sp. nov.

Plate XV.

Figs. 1–3.— *Cecidomyia ? semenivora* sp. nov.
Fig. 4.— *Cecidomyia ? semenivora*, anchor-process.
Fig. 5.— *Lasioptera nodulosa* sp. nov.
Fig. 6.— *Lasioptera nodulosa* anchor-process.
Fig. 7.— *Cecidomyia ? vernoniæ* sp. nov.
Fig. 8.— *Cecidomyia ? vernoniæ*, anchor-process.
Figs. 9 and 10.— *Cecidomyia ? meibomiæ* sp. nov.
Fig. 11.— *Cecidomyia ? meibomiæ*, anchor-process.
Fig. 12.— *Lasioptera farinosa* O. S., anchor-process.
Fig. 13.— *Lasioptera farinosa* O. S.

Plate XVI.

Figs. 1 and 2.— *Cecidomyia ? verbesinæ* sp. nov.
Fig. 3.— *Cecidomyia ? verbesinæ* anchor-process.
Fig. 4.— *Cecidomyia ? eupatoriflorœ,* sp. nov.
Fig. 5.— *Cecidomyia ? eupatoriflorœ,* anchor-process.
Fig. 6.— *Asphondylia conspicua* O. S.
Fig. 7.— *Cecidomyia impatientis* O. S.
Fig. 8.— *Cecidomyia impatientis,* anchor-process.
Fig. 9.— *Cecidomyia umbellicola* O. S.
Figs. 10 and 11.— *Cecidomyia vaccinii* O. S.
Fig. 12.— *Cecidomyia vaccinii,* anchor-process.

Plate XVII.

Fig. 1.— *Cecidomyia ? pustuloides* sp. nov.
Fig. 2.— *Cecidomyia ? pustuloides,* anchor-process.
Fig. 3–5.— *Lasioptera ? linderæ* sp. nov.
Fig. 6.— *Lasioptera ? linderæ,* anchor-process.
Figs. 7 and 8.— *Cecidomyia ? ramuscula* sp. nov.
Fig. 9.— *Cecidomyia ? ramuscula,* anchor-process.
Fig. 10.— *Cecidomyia ?* persicoides O. S., anchor-process.
Figs. 11 and 12.— *Lasioptera viburnicola* sp. nov.
Fig. 13.— *Lasioptera viburnicola,* anchor-process.
Fig. 14.— *Cecidomyia racemicola* O. S.
Fig. 15.— *Cecidomyia racemicola,* anchor-process.
Fig. 16.— *Asphondylia globulus* O. S.

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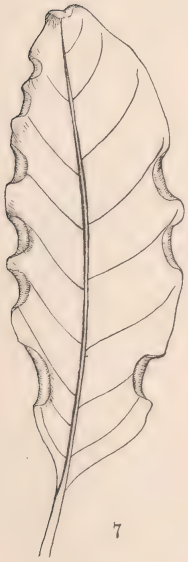

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E.L.Beutenmuller

Gall-Producing Cecidomyiidæ.

GALL-PRODUCING CECIDOMYIIDÆ.

Gall-Producing Cecidomyiidæ.

Gall-Producing Cecidomyiidæ.

Gall-Producing Cecidomyiidæ.

Aros Cañon near Guaynopita.

The river here is about 1600 meters below the distant rim. The inner gorge, 600 meters deep, shows the angular form characteristic of youthful drainage.

55.(72.1)

Article XVIII.— A GEOLOGICAL RECONNAISSANCE IN THE WESTERN SIERRA MADRE OF THE STATE OF CHIHUAHUA, MEXICO.

By Edmund Otis Hovey.

Plates XVIII–XXXV.

Text Figures 1–13 and a Map.

The elevated plateau or series of plateaux forming the principal portion of Old Mexico rises irregularly toward the south from about 1220 m. above the sea near Ciudad Juarez, opposite El Paso, Texas, to about 2250 m. near the city of Mexico along the line of the Mexican Central railway. West of this line the rise is more rapid along a series of bolsons separated by mountain ranges from the bolsons traversed by the Mexican Central road, and the 2200 m. level for portions of the plateau is attained about 160 km. northwest of Chihuahua. The general plateau ends toward the east in the series of mountain ranges known as the Sierra Madre del Oriente and towards the west in the Sierra Madre del Occidente. Toward the south the plateau feature is lost in the maze of mountain peaks south and west of the City of Mexico. Felix and Lenk[1] consider the plateau to be cut off at the south by a nearly east and west fault along the valley of the Balsas River, but Aguilera has refuted this idea in his brochure entitled "Sobre las condiciones Tectónicas de la República Mexicana."[2] Toward the north the plateau merges into the high plains of Arizona and New Mexico.

The general geology of the Mexican plateau has been discussed by several writers, but the detailed structure is comparatively little known. Its quadrilateral form and the arrangement of the mountains along great continental structure lines have been made clear by R. T. Hill. The volcanoes have been studied by Ordoñez, Waitz, Farrington and others, the mining geology by Ordoñez, Böse, Hill, Weed and Kemp among recent writers. The real character of the Western Sierra Madre, however, seems to have been unknown or overlooked and large areas of the region have been left uncolored on the geological maps of the country or colored generally for rhyolite, as was done by Ordoñez in the map accompanying Bol. Inst. Geológico de Mexico, No. 14, 1900.

[1] Zeits. d. deutsch. geol. Gesell., Vol. XLIV, pp. 303–323, 1892.
[2] Mexico. Tip. de la Sec. de Fomento. 1901.

The development of the vast natural resources of the Western Sierra Madre has been retarded by the great landed proprietors of the country, who have merely desired extensive ranges for their cattle and have discouraged exploration, in spite of the wonderful riches which have been taken from the mines at sundry points. The demand for timber for the mines of Arizona, New Mexico and northern Sonora, the known or suspected existence of valuable ores of gold, silver and copper, and favorable changes in the Mexican laws have, however, attracted the attention of American capitalists, as a result of which the country is gradually opening up.

One of the parties exploring a portion of the region was under the leadership of Robert T. Hill, formerly of the United States Geological Survey,

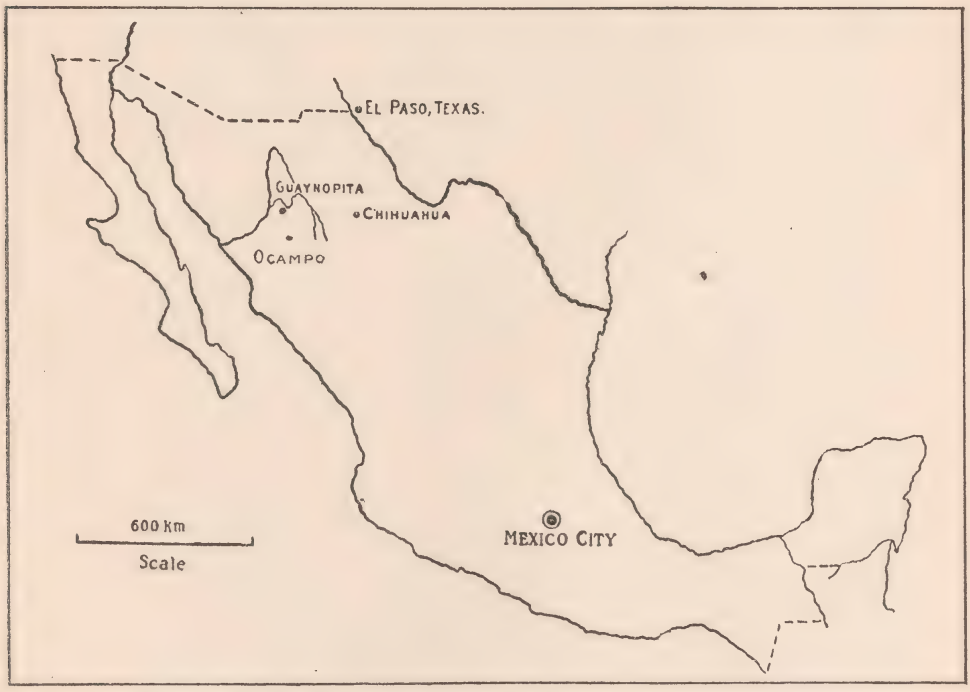


Fig. 1. Outline map of Mexico showing location of the district discussed.

and was formed for the purpose of studying the conditions of mineralization in the mountains. The American Museum of Natural History was invited to send the writer with the party for the purpose of studying the physiography and general geology of the region traversed and to make collections of photographs and rocks for the Museum.[1] The expedition left El Paso 14 February, 1905, and spent about seven weeks in the Western Sierra Madre. The present article is based upon the joint observations of the

[1] The other members of the party were John Seward, mining engineer, and Frank H. Fayant, journalist.

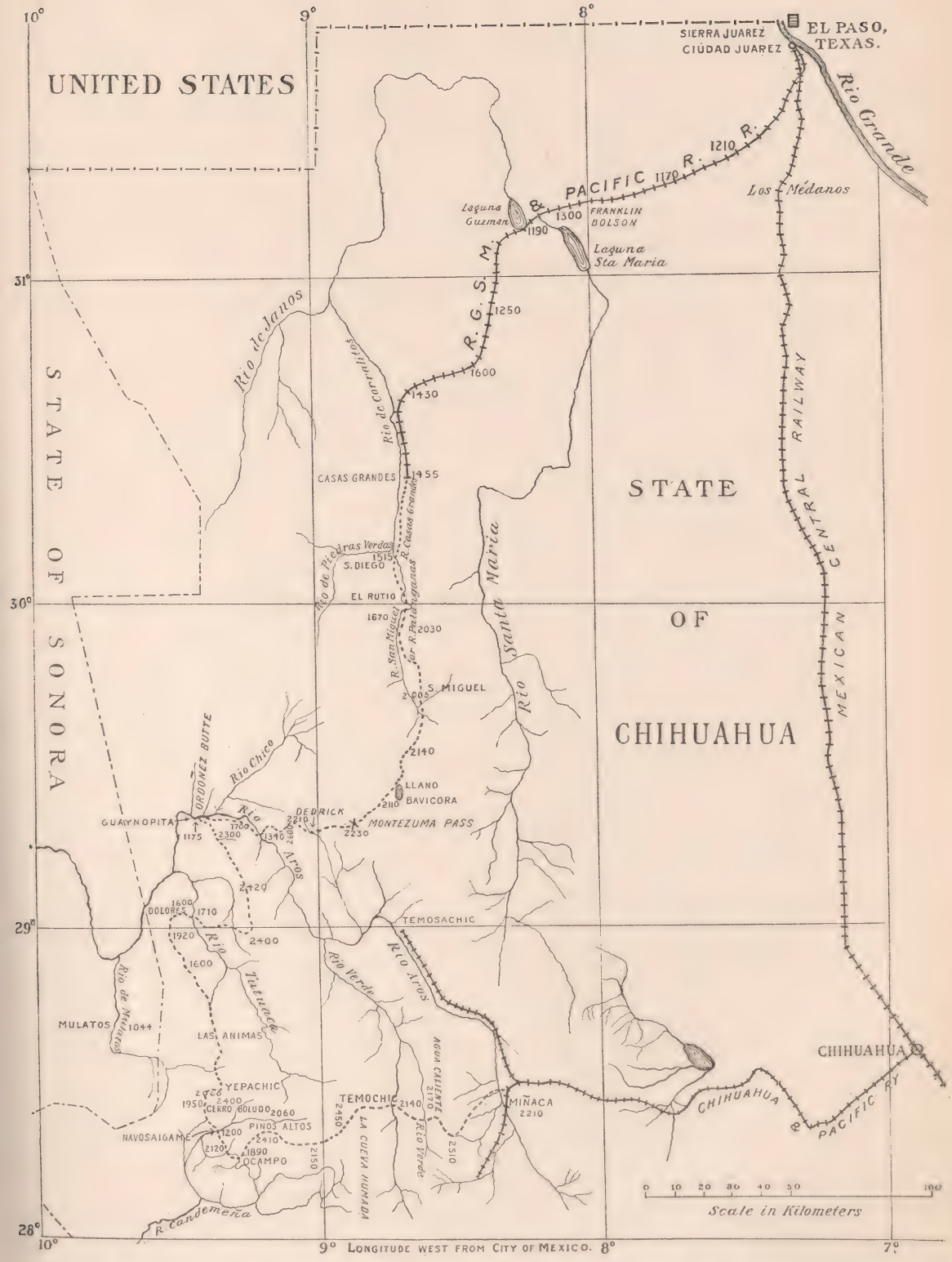


Fig. 2. Sketch map of the northwestern portion of the State of Chihuahua, Mex., showing by means of the railroads and the dotted line the route traversed by the writer in February–April, 1905. The numbers give elevations (mostly aneroid determinations) in meters.

two geologists of the party, who had the privilege of traversing together a heretofore practically unknown region, geologically speaking.

The route followed was from Ciudad Juarez southwestward 150 miles over the Rio Grande, Sierra Madre and Pacific railroad to the then terminus for trains at Nuevas Casas Grandes; thence southward 125 miles by wagon and pack train through Hacienda San Diego, Hacienda El Rutio, Cañon of the San Miguel, Hacienda San Miguel, Llano Bavicora and Montezuma Pass to the lumber camp of Dedrick; thence westward 32 miles across and along the Aros (Yaqui) river and cañon to the mining camp of Guaynopita; thence southward 125 miles by way of the divide between the Aros and Tutuaca rivers, Dolores, Las Animas, Yepachic, Cerro Boludo (or Voludo) and Navosaigame to Ocampo (Jesus Maria); thence northward and northeastward 100 miles by way of Pinos Altos, La Cueva Humada, Temochic and Agua Caliente to Miñaca, which was then the terminus of the Chihuahua and Pacific railway; thence by rail 120 miles east to Chihuahua and from there 225 miles north to Ciudad Juarez, completing the circuit. The journey from Dedrick to Miñaca was accomplished altogether on mules and with pack train.

The region has not been visited frequently by tourists or investigators, and but three recent publications regarding it have come to the writer's notice. John R. Bartlett, United States Commissioner on the Mexican Boundary commission, 1850–1853, traversed the northern part of the State of Chihuahua from the west in 1852, visiting Janos, Corralitos and Casas Grandes[1] and going out across the mesa to Ciudad Juarez, then known as El Paso del Norte. Bartlett's narrative gives a good idea of the difficulties encountered by travelers only a half-century ago and some notion of the surface features of the route followed, but the most important part of the account is that describing the ruins at Casas Grandes. In 1884 A. F. Bandelier, then carrying on explorations for the Archæological Institute of America, crossed the Western Sierra Madre from the west forty miles south of the international boundary and, turning southward, studied the prehistoric ruins as far as a point thirty-five miles southwest of Casas Grandes. Bandelier penetrated nearly to the high plateau of the Sierra Madre before he was obliged to turn back, and he writes regarding the region:[2] "If the interior of the Sierra Madre is ever opened to travel and civilization, it will be found prolific in resources of divers kinds, and as interesting to the naturalist as to the student of archæology." Carl Lumholtz also visited Casas Grandes in 1891, and in 1892 he traversed much of the country described in the present article. In his book "Unknown Mexico"[3] Lumholtz

[1] Personal narrative, Vol. II, pp. 339–379. 1854.
[2] "Investigations in the Southwest," Part II, p. 563.
[3] Scribners. New York. 1902.

has treated of the archæology and ethnology and has written somewhat of the wonderful scenery of the region, including the Aros cañon at Guaynopa, a few miles west of Guaynopita.

The region falls naturally into three subdivisions: the desert and semi-arid country from Ciudad Juarez to El Rusio, 16 km. south of Hacienda San Diego; the high plateau country which is covered with oak or pine according to altitude and dotted with grassy prairies, including the Llano Cristo (Hacienda San Miguel), Llano Bavicora and similar "enclosed basins," and the cañon district through which in its ramifications the rivers descend from the high plateau to the deserts or to the lowlands and the ocean, and containing numerous mesas, or tablelands, which are the remnants of ancient inclosed basins.

Leaving the banks of the Rio Grande at Ciudad Juarez, alt. 1125 m.[1] the Rio Grande, Sierra Madre and Pacific railway skirts the eastern and southern base of Sierra de Juarez, or Cerro Muleros, slowly rising till at km. 22 the level of the great Mesa, or table-land, is attained, 135 m. above the Rio Grande. This plateau corresponds in position with the highest terrace along the El Paso and Southwestern, Southern Pacific and Santa Fé railroads a few miles west and northwest of El Paso and is similar to that in appearance and constitution. Wastes of sand and arid soil, held in place to some extent by bunch grass, greasewood and mesquite, stretch away in every direction, and the monotony of the plain is relieved only by the summits of the half-buried mountains, mostly volcanic in origin, which are to be seen here and there. These mountains have played a rôle in the formation of the mesa to which reference will be made later.

The mesa presents a rather abrupt terrace-like face to the immediate valley of the Rio Grande, but the upper surface of the table-land slopes gently away therefrom. This disposition of the surface together with the dryness of the climate, has prevented the weak drainage of the mesa from forcing its way to the Rio Grande, while the paucity of the rainfall renders extremely slow the robbing of the mesa drainage by the drainage of the Rio Grande. The surface of the mesa rises almost without a break into the bordering and included mountains and ridges.

Near km. 38 the railroad passes through the almost completely buried outliers of the Sapello Mountains. These seem to be of well-bedded Cretaceous (?) limestone standing almost on edge and apparently are the southern extension of the beds exposed in Juarez Mountain. At km. 45 the road enters the region of Los Médanos which it crosses transversely for thirty kilometers. The "médanos" are moving dunes of barren sand, some of

[1] The altitudes and distances along the railway are taken from the official map and profile of the road.

them low, but others 20 to 60 m. or more in height, and the region which they characterize extends for more than one hundred miles from near the international boundary southeastward beyond the Mexican Central railway. The strip is comparatively narrow, the section of the Sierra Madre and Pacific railway being made at nearly the widest part. The plain here is about 1210 m. above the sea. Destruction of the sparse vegetation in any part of the mesa is liable to cause drifting of the sand under the influence of the strong winds which prevail during a large part of the year. Sometimes the drifts cause serious interference with railroad operation. Where the dunes cross the Sierra Madre road they are only 5 to 6 m. high.

The effect of the mesquite is not only preservative but also constructive. The plant is normally a tree fifteen to twenty feet high, but on the desert the portion usually above ground is only the ultimate branches, the trunk and heavier branches being below the surface. Sand and soil drift into oval mounds with north-south axis around the mesquite trees and bunch-grass takes root on the surface. Kangaroo rats burrow deeply into the mounds, and other creatures find refuge or food there. The arid districts teem with life in surprising manner. The mesquite and the greasewood (*Covellia*) are practically the sole source of fuel in the arid region and the mountains furnish water by irrigation canals or flumes, hence the inhabitants are said to "dig for food and climb for water." Furthermore they "cut hay with a hoe," since the bunch grass, green or dry, furnishes fodder for cattle and horses and is gathered by pulling it up by the roots.

From km. 70 to km. 75 the railroad descends rather rapidly 35 m. through well-developed "bad-land" topography on a small scale to the floor of an extensive basin 1170 m. above the sea, or 90 m. below the rim of the mesa where it overlooks the Rio Grande. The basin is almost perfectly flat and is 15 km. across by the railroad. This is the Franklin bolson, or pocket desert, and a small portion is occupied by a shallow laguna or lake during part of the rainy season. Between km. 95 and km. 120 the railroad cuts through the tops of a range of "buried mountains" known as the Sierra San Blas, consisting of limestone ridges associated with basaltic cones and flows. The cones seem to be destructional forms.

Here again the surface of the mesa rises in suggestive fashion into the gulches and around the buried tops of the associated mountains, showing abundantly the "conoplains" recently described by Miss Ogilvie.[1] This feature, the nature of the recent deposits and the condition of the rock-fragments lying upon the mountain sides everywhere throughout the arid regions indicate the arid, or desert, cycle of subaërial denudation as dis-

[1] Amer. Geol., vol. XXXVI, pp. 27–34, 1905.

tinguished from the "normal" cycle obtaining in well-watered districts.[1] The original recent land surface was formed of folded limestone ridges and lava flows and fragmentary ejecta; it comprised many constructional valleys and basins. The great diurnal variations in temperature, often amounting to 100° F. (Libby) in these regions, subject the rock ledges and fragments to severe strains, causing continual flaking or spalling and continual reduction in the size of the rock masses, even without the aid of frost. The resulting masses, both large and small, descend the slopes by gravity and are in turn attacked by the disintegrating and decomposing forces. Occasional showers, even in the semi-arid regions, cause sheet-flood transportation and erosion and transfer much material to the depressions in the surface. The winds transport vast quantities of sand and even small pebbles, though the rate of transportation is probably slower and more uneven than it is with water. Whirlwinds too are important agents of transportation in the desert. When deposited in the temporary or permanent lagunas, or lakes, the transported material is laid down in well-stratified beds, some of which are the adobe clay of the arid-regions.

An important feature of wind erosion and deposition is that they are not determined by any base level, as is the case with water. Wind scoops out hollows below the general level of the land and carries its load of sand to higher as well as to lower positions. The distance to which the material is carried depends upon its coarseness of grain and the violence of the wind. The fine sand and dust are transported far and wide. The exposed surfaces of pebbles, boulders and cliffs show the wearing and polishing effects of the wind-driven sand. The tops of many buried mountains are to be seen on the journey across the dry mesa. As has been noted by Davis, when the internal drainage does not escape from the forming basins, the tendency of the wash, slide-rock and small fragments is to fill the basins with deposits whose limiting position is one of horizontality. Measurements were not made to determine the distance to which fragments of a given size have traveled into the basin from the surrounding parent ledges, but in general it may be said that the finer material is in the central portion of the basins. This, however, is not due to simple transportation, as the process of disintegration is continuous and progressive.

At km. 125 from Juarez the railroad reaches Laguna de Guzman, a body of water about 40 km. long from southeast to northwest and 15 to 25 km. wide. The lake is shallow, however, and its dimensions, area and shape vary greatly with the seasons. The evaporation is said to exceed 2 m. a year, and it is not a rare occurrence for the lake to become entirely

[1] See the writings of W. M. Davis, R. T. Hill, C. R. Keyes de Lapparent, McGee, Penck, Walther and others.

Fig. 1. Franklin Bolson on the R. G., S. M. and P. R. R.

A typical arid "bolson," or pocket desert, 86 km. from El Paso. Slight depressions in the surface collect water during showers and form "settling tanks" for the deposition in stratified beds of wind-driven sand and dust.

Fig. 2. Corralitos Basin and Sierra de Corralitos from the R. G., S. M. and P. R. R.

A typical semi-arid basin 200 km. from El Paso, receiving sufficient moisture during the winter to support an extremely scanty vegetation.

dry. Laguna de Guzman receives the drainage of the Casas Grandes river, but the discharge into the lake is diminishing year by year on account of the extended irrigation projects along the middle course of the stream. Within a few kilometers on the other (south) side of the railroad track is the similar body of water known as the Laguna de Santa Maria, which is the receiving basin of the Santa Maria river, a stream running nearly parallel (N. N. W.) with the Casas Grandes much of its course. The water of the Guzman laguna is too alkaline to be fit for drinking, but copious springs of sweet fresh water are found in the vicinity. West of the laguna rises the mountain mass known as the Sierra de Guzman, consisting principally of volcanics. Warm springs are known at the east base of these mountains.

Turning to the south from Guzman station the railroad passes into an inclosed basin in which is a large laguna. The Urrutia mountains, known also as the Corral de Pedro, bound the basin on the west with a series of small cones and lava flows. These, like the opposite mountains, the Sierra Santa Maria, east of the railroad, are of volcanic origin. From the passing train one readily determines the nature of many slopes to be dry wash consisting of coarse and fine, subangular and rounded fragments, pebbles and boulders. The process of sorting and transporting is evident. South of the Urrutias are the Sabinal mountains, 156 km. from El Paso. The Sabinal range is reported to have a core of granite, upon which rest at high angles beds of Cretaceous limestone. The granite is an intrusive mass, to judge from the reports of mine owners of the region. Carbonate ores of lead and silver characterize the contact zone and are worked by the Sabinal and Adventurera groups of mines. This area of granite and limestone is charted upon Castillo's geological map of Mexico. The station of Sabinal is in an inclosed basin at 1250 m. above tide, or 80 m. above the Urrutia basin.

Near km. 170 the railroad turns to the southwest and begins to climb rapidly to surmount the pass of San Pedro between the high Sierra Capulin on the north and northern outliers of the lower Sierra Escondida on the south. These outliers from near km. 175 to near km. 190 (the station of San Pedro is at km. 188) present a series of comparatively low, flat-topped buttes or table mountains, the upper portion of which consists of columnar lava, probably basaltic in character. They have been carved from an extensive sheet of lava overlying the beds of tuff or breccia.

At km. 193 the railroad crosses the pass at an elevation of 1600 m. and enters the Corralitos basin, the scanty drainage of which has been captured by the Casas Grandes river, if one can speak of "drainage" in such an arid basin. The San Pedro group of silver-lead mines is in the contact zone between Cretaceous limestone and underlying intrusive granite in

the old pass of the same name about 8 km. north of the railroad. The railroad descends 190 m. in 25 km. to km. 218 (the station of Corralitos is at km. 215). Near km. 222 the road enters the Casas Grandes basin, altitude 1455 m., which extends a distance of about 30 km. to the new town of Terrazas.

The Casas Grandes basin is typical of the semi-arid inclosed basins, now traversed by rivers, which are to be found scattered throughout the Sierra Madre region. Its surface is almost perfectly level, the railroad rising from north to south across it at a grade averaging .2 of 1 per cent, and the river, the Casas Grandes, is nearly at base level, doing scarcely any erosion except in times of flood. The plain at the north end of the Casas Grandes basin is dotted with small conical hills of columnar basalt covered with loose angular blocks of rock, and a great area of this character stretches away to the southeast. These low cones are destructional forms and show almost the last stage in the burying of a mountain. The eastern portion of the basin shows symmetrical destructional cones of volcanic material apparently basaltic in character. The mountains on the west of the basin are the foothills of the main cordon of the Western Sierra Madre. They rise to greater elevations than do those to the east. The basin is about 35 km. wide from west to east and is very fertile along the river where irrigation is practicable. The Mormon colony "Colonia Dublan" is a thriving recent settlement in the midst of the basin. In exceptionally rainy years even the "dry" ranches are productive of much grass.

That the pre-Columbian inhabitants of the region valued this basin as a place of residence is shown by the extensive ruins to be found upon a terrace of the river at the place known by reason of these remains as "Casas Grandes," *par excellence*. The ruins cover a surface several acres in extent, and are supposed by Bandelier[1] to have housed a population of between 3,000 and 4,000 souls. The adobe of the ancient walls consists of the red clay of the district mingled with gravel and laid in troughs, one tier being allowed to set before the next tier was laid atop of it, just as concrete buildings are put up today in our own and other countries. This ancient adobe, which is certainly more than 400 years old, gives some notion of the extreme slowness with which erosion goes forward in a semi-arid climate. In this part of the region the ground is largely covered with scanty grass and other vegetation, which undoubtedly prolongs the period of erosion through preventing the winds from taking up a heavy load of sand to hurl against obstacles.

[1] Investigations in the Southwest, part 2, p. 544. 1892.

Modern adobe differs from the ancient in being made of clay mixed with straw and formed into large bricks. The resulting material is not nearly as durable as the ancient, and the difference between the two is strikingly brought out in several structures at Casas Grandes in which the modern inhabitants have built the ancient ruins directly into the walls of the new houses. Some of the ruins contain rooms, the walls of which have been finished by a plaster made of sifted adobe clay and laid on smoothly. Much excellent pottery of good design and workmanship has been found in the ruins, and the indications are that the unknown inhabitants were of a comparatively high degree of civilization. They probably were driven out of their homes or exterminated by the attack of some hostile tribe of Indians. The modern Mexican town of Casas Grandes straggles over the river terrace, and its inhabitants depend for their meager subsistence upon the grazing and the frequent crops raised by rather primitive methods of irrigation along the river.

Blue limestone (of Cretaceous age?) is reported to exist in the mountains west and south of the Casas Grandes basin.

About 10 km. south of the railway station of Casas Grandes the inclosed basin of the same name ceases against rhyolitic hills. Four km. further south the rock is a much-indurated rhyolitic tuff presenting fine-columnar structure. The rhyolite is overlain by beds of scoriaceous basaltic lava in the cavities of which there is much secondary chalcedonic silica. This is at the junction of the San Miguel and Piedras Verdes rivers, which unite to form the Casas Grandes. These rivers well illustrate the confusion of names as applied to streams in Mexico. The river, here called the Casas Grandes, extends from the junction of the forks just mentioned to the Laguna de Guzman, flowing a distance of 240 km. Its upper half is known by the name of Casas Grandes, while the lower half is called the Corralitos river on some maps. Above the junction point the San Miguel, which is also known as the Palanganas, is the real continuation of the Casas Grandes, and should not receive an independent name. The Casas Grandes river decreases in size as it proceeds on its course below the town of Casas Grandes. Evaporation and irrigation remove more water than the arid region replaces.

The two forks of the Casas Grandes river come together in the northern part of the San Diego basin, which is the eighth of the bolsons and basins through which we passed after attaining the mesa south of Sierra de Juarez. It is a small basin, about 24 km. long from N. N. W. to S. S. E. by 16 km. wide; elevation about 1500 m.[1] above the sea. Since its drainage was

[1] All the following altitudes are given from readings of an aneroid barometer, unless otherwise stated.

captured by the Casas Grandes river alluvial fans have become rather prominent along the rim. There still exist transverse "trincheras" or low dikes of stones and earth which were built in pre-Columbian time for the purpose of preventing the displacement by rains and simple sliding of the soil needed for cultivation. The San Diego basin is bounded by steep mountain walls which increase in altitude toward the south until at El Rutio they rise 600 to 700 m. above the plain and rapidly close in upon the river, the San Miguel, which debouches near this point from a picturesque cañon.

In the northern part of the San Diego basin there is a melon-shaped hill consisting of basalt. This flow is older than a portion at least of the basin deposits, inasmuch as it has been partly buried by them. In several districts in Chihuahua and in southern New Mexico and Arizona the dissected basins and bolsons show a similar intercalation of comparatively recent flows of basaltic lava, and basalt also occurs in some of the lower beds of the Aros cañon. The melon shape of the hill is a peculiar feature which perhaps may be explained by assuming that the bed lies over a vent through which the lava welled up with comparative gentleness. Near the junction of the Piedras Verdes river with the San Miguel a flow of scoriaceous basalt lies directly upon a thick flow of rhyolite.

The San Diego basin forms the major portion of the hacienda, or estate, of the same name belonging to General Luis Terrazas, a hero of the Mexican contest against the French in the 60's and for many years governor of the state of Chihuahua. General Terrazas is probably the largest individual landed proprietor in the world. His haciendas comprise millions of acres of the best land of Chihuahua and are said to extend in a practically unbroken series for 500 km. across the State. An administrador is in control of each hacienda, and under him there is a little army of servants, farm hands and cattlemen. Existence on these estates is still usually one of almost feudal simplicity, each hacienda being practically self-supporting. The energies of the haciendas are directed toward the production of cattle, horses and mules, with only agriculture enough to raise sufficient corn (maize) for local consumption and the carrying of stock over exceptional seasons. The agricultural work of the country is carried on in most primitive fashion. Single-handled wooden plows are in use which are made from the natural knees of tough trees like the live-oak. Sometimes the point of the share is protected by a bit of iron, but the implement is, at best, a very crude affair which entails an enormous waste of labor in its use. Specialized and efficient farm implements are making very slow headway in the Republic of Mexico, on account of the poverty and conservatism of the farming population.

Fig. 1. San Miguel Cañon.

Upper reaches looking N. W. from near Arroyo Metate. Total depth of cañon about 800 m. Rocks are rhyolite and andesite flows and tuffs and basalt flows.

Fig. 2. San Miguel Cañon near Arroyo Metate.

The lower gorge, some 150 m. deep, has been cut in a heavy composite bed of rhyolite. Many caves in the cañon were once occupied by human inhabitants.

At the southern end of the San Diego basin at an altitude of about 1,600 m. above the sea, we plunged directly into the cañon of the San Miguel river. This gorge has been carved to a depth of about 800 meters through a succession of flows of andesite, rhyolite and basalt, alternating with beds of corresponding tuffs. At the mouth of the cañon augite-andesite is the basal rock and is partly covered by a flow of basalt. The basalt is perfectly fresh and may be the youngest rock of the section in spite of its low relative position. Flow structure is strongly in evidence in the lava beds and some of the tuff beds have been considerably indurated. The region occupied by the great gorge is estimated to be 7 or 8 km. wide. The region is one of moderate vegetation, and the mountain slopes are covered with grass and a scanty growth of small live oaks and jack pines. The whole section exposed, from Hacienda San Diego to the top of the Cordon del Metale, is about 900 m. thick.

After following up the cañon for a distance of 10 or 12 km. we turned abruptly to the east and climbed out of the gorge by way of the Arroyo Metate and a neighboring arroyo to the south and crossed over the Cordon del Metate at an altitude of about 2200 m. The view across the cañon to the westward shows that it consists of a well-dissected plain between the bounding walls and that the main river flows through a comparatively youthful gorge which it has cut in the lowest exposed bed of solid rhyolite. This bed is about 150 meters thick, and is at least double in make-up, for 12 m. above the river we observed a thin bed of tuff in it separating an earlier from a later flow. The upper surface of the lower bed is scoriaceous and contains rounded masses of relatively dense rock which may be the remains of ancient bombs. The flows are columnar in structure with platey parting near their upper and lower surfaces. Above this bed of rhyolite there are apparently several of andesite and an upper flow of rhyolite in the composition of the walls of the cañon. Roughly speaking, we have the following section on the San Miguel (Palanganas) river from the junction with the Piedras Verdes river to the summit of the Cordon del Metate, which forms the eastern wall of the main San Miguel cañon; rhyolite flows and tuffs associated with basalt, 100 m.; augite andesite overlain by basalt, 160 m.; rhyolite flows and tuffs, 150 m.; augite andesite flows and tuffs 350 m.; rhyolite flows and tuffs, 240 m. There was a considerable interval of erosion between the uppermost andesite flow and the overlying rhyolite.

The intercalated tuff beds have given opportunity for the formation of the vertical walls of the arroyos and the cañon, since they have been eroded at a more rapid rate than the beds of solid rock, thus undermining the latter. Furthermore, the planes of separation between the lava beds and the contact zones between the lava and the underlying tuff are the locus of many shallow caves, some of which in time past have been used as human habitations.

Crossing the Cordon del Metate we came out upon the Llano Cristo, another inclosed basin about 30 km. long from north to south, at an elevation of about 2150 to 2180 m. above the sea, or more than 700 m. above the Casas Grandes basin. Llano Cristo, however, is not a simple flat plain, but is rather a series of basins at practically the same elevation. The surrounding mountains rise from 200 to 250 m. above it. The surface of Llano Cristo seems in part at least to be the original surface of a great flow of andesite, the hollows of which have been filled more or less completely with wash. Here and there rhyolite is in evidence at a higher level, as is shown in the section given above.

Most of the drainage is entirely internal, but toward the south the head waters of the San Miguel river and some of its branches have cut back into the plain, and the San Miguel cañon heads near the manor house of the Hacienda San Miguel. The soil of the Llano Cristo is fertile and produces fine grass and crops of maize without irrigation. The hacienda of San Miguel, which includes the Llano Cristo, is one of the best of those belonging to General Tarrazas, comprising more than 1,000,000 acres of land and supporting even with the primitive methods employed 40,000 head of cattle. Eight thousand steers are branded yearly. Two hundred persons live at the manor house, which is a regular fortification, built to withstand the attacks of roaming bands of Apaches and other hostile tribes of Indians.

South of the house the plain is marked by two series of prominent terraces along a tributary of the San Miguel. The upper of the two terraces rises gradually into the wash from the mountains and contains gravel which is partly consolidated. The San Miguel (Palanganas) river has its source in the so-called "continental divide" about 30 km. south of the manor house. The term continental divide is misleading in a region like the Western Sierra Madre, where the relationships of the chief cordons are confused by the great eroded cañons and valleys; where there is so much internal drainage in high basins, and where the division at best is between oceanic (Pacific) and interior drainage, since none of the rivers originating on the eastern slopes of these mountains, with the exception of the Conchos, reaches oceanic (Atlantic) drainage.

After leaving the Llano Cristo basin our route southward led us across low ridges and small basins at elevations of 2100 to 2170 m. above the sea in which are several "cienegas," or marshes. The ridges are rocky and are sparsely timbered with an open forest of large long-leafed pine trees, but the basins are, as usual, covered only with grass. It is a fine grazing country. The ravines show much scoriaceous lava, probably andesitic in character, but the higher portions of the ridges and the plateau are evi-

Fig. 1. Llano Bavicora.

A typical inclosed basin with an almost perfectly level floor of "wash" from the disintegration of the neighboring and included mountains. In the distance is the top of a flow of basalt.

Fig. 2. Llano Bavicora.

Detail of a promontory of basalt, showing the rock in the process of disintegration, degradation and transportation.

dently part of a great flow of rhyolite. About 40 km. from the hacienda house of San Miguel we entered the Llano Bavicora, a vast level expanse which forms the heart of the rich million-acre tract belonging to the Hearst estate.

The Llano Bavicora is a typical inclosed basin about 50 km. in length from northeast to southwest by about 32 km. in width. Its drainage seems to be entirely internal, and a laguna occupies a shallow depression in the middle, receiving the discharge of four or five considerable but variable streams. The basin occupied by the laguna is so shallow that the area covered by the waters and the outline of the shores vary greatly with the seasons. The general elevation of the plain is about 2110 m. above the sea. Low flat tongues of rhyolitic wash come far out into the basin from the low surrounding mountains. Opal and chalcedony pebbles are abundant in the wash. These are so numerous indeed that silica in this form must play an important part in the total of material. Many ledges of rhyolite and some of basalt border or jut out into the Llano Bavicora like the bluffs and headlands along the shores of the ocean. The bold capes, peninsulas and islands of lava are covered with residual boulders showing the gradation from ledge to soil. The degradation of the basalt progresses more rapidly than that of the rhyolite beds.

Our route across the Bavicora plain had been from northeast to southwest, but at the border we turned westward and plunged into the forest, slowly rising from the time we left the plain until Montezuma Pass was reached at altitude 2230 m. on the divide between the Bavicora drainage and that of the Aros river. The pass receives its name from an assemblage of about two hundred mounds marking the location of a large village of supposed pre-Columbian origin. At the time of our visit the mounds had never been investigated or studied, but such a state of affairs can not be expected to obtain long, with the increase of American travel through the region. Fifteen kilometers west of Montezuma Pass we reached the new lumber camp of Dedrick in the midst of the heavy pine forest at an elevation of about 2210 m. above tide, upon the little creek known as the Chuchupati, which flows southward as a consequent stream until it breaks across the cordon and empties into the northward flowing Aros river, a member of the Pacific drainage system.

The region immediately about Dedrick is composed of rhyolite flows and tuffs. The flows are both lithoidal and vitreous. The obsidian is brown, black and pearl gray in color, and is both heavily massive and platey in structure. Some of the platey rock is a very glassy rhyolite which has suffered much from devitrification. The obsidian shows beautiful lines of flow, either all black or alternating brown and black, and much of it is

perlitic in texture. The brown is often the matrix for rounded masses of the black. Fragments of obsidian are abundant in the tuff. The most striking feature of the petrography of the surface of this portion of the plateau is the predominance of andesite, in contrast with the prevalence of rhyolite to the east and south of this region, as described by Ordoñez. The great mountain ridges rising above the high plateau seem generally to be of rhyolite, and they contain much obsidian as well as lithoidal lava.

About five kilometers west of Dedrick we reached the rim of the vast cañon of the Aros river, the trail passing over the divide at 2565 m. (average of two readings) above tide. At this altitude there occurs a rather fine-grained soft conglomerate 20 m. thick containing rounded and subangular fragments of obsidian and other igneous material too much decomposed for identification. This deposit seems to be consolidated stream wash from the neighboring ridge. On the south side of the pass over which the trail has been made the ridge of rhyolite rises to an elevation of probably 2775 or 2800 m., which seems to be about the maximum elevation of the highest portions of the cordons in this part of Chihuahua.

The view across the cañon of the Aros is superb. The cañon is estimated to be 12 to 16 km. wide and the river is from 1450 to 1600 m. below the highest portions of the rim. Innumerable beds of lava, indurated tuff and basin conglomerate or sandstone expose vertical faces of more or less brightly colored rock, contrasting in pleasing fashion with the grass-covered talus slopes and the forests of pine or live-oak, according to altitude, while the crimson trunk of an occasional madroña tree and the pale greens of the cacti and the magueys add charming variety to the foreground of the scene.

The west-facing slopes of the eastern wall of the cañon are steeper than the east-facing slopes of the cañon and of the region east of the cañon. This is an indication that the degradation of the plateau is proceeding eastward and shows how the Pacific drainage has robbed the internal drainage of the basins of the central part of the Western Sierra Madre and is carrying the process farther eastward. The diurnal variation of temperature is greater on a west-facing slope than on an east-facing slope, on account of the higher heating power of the afternoon sun as compared with the morning sun, while the nocturnal temperature is presumably the same on both slopes. The greater the variation in temperature the greater the strains produced in the rocks and the more rapid the disintegration. The prevailing winds come from the west bringing moisture from the Gulf of California. This moisture is almost all precipitated in the high mountains, and the rains are driven against the western slopes by the prevailing winds and are thus an aid in removing the rock débris.

The trail to the river leads down through a maze of side gorges, along sharp divides between deep ravines and across a level plain which is the remains of an inclosed basin. Nearly 450 meters below the summit of the pass we came upon an extensive flow of augite-andesite 45 or 50 meters in thickness. The rock thus identified is black when fresh, with prominent phenocrysts of plagioclase (labradorite?). The altered zones of the mass show the feldspar phenocrysts changed to dark red in color. Under the microscope the rock is seen to have an extremely fine-grained hyalopilitic groundmass with porphyritic augite crystals subordinate in prominence to the plagioclase. The augite phenocrysts show resorption phenomena and sometimes their presence is to be inferred only from aggregates of minute magnetite crystals. The plagioclase phenocrysts, which contain many microlitic inclusions, are not excessively twinned, the basal cleavage is well marked and the angle of extinction on (001) of 30° is taken as indicating a feldspar at least as basic as labradorite. The ground-mass contains but little glass and what there is is light brown in color. Pyrite is a rare constituent in very small crystals.

About 500 meters below the pass we traversed for several kilometers the level top of a mesa formed by the local conglomerate and sandstone of an ancient inclosed basin which has been deeply incised by tributaries of the Aros river since its drainage was captured by the master stream. We estimated the maximum thickness of these basin deposits to be not less than 150 m. but they are variable in development, their base being the uneven surface of the original lava flows. We have spoken of "buried" mountains in the bolsons of northern Chihuahua, but here in this cañon we might as appropriately speak of "resurrected" mountains, since old peaks once covered by the accumulation of débris in the inclosed basin have been uncovered again by the dissection of the basin since the capture of its drainage by the Aros. A resurrected mountain of andesite is shown in the illustration, pl. XXII.

The number of lava flows in the region has been great. In one unimporant side arroyo were counted 19 well-marked beds of lava, aside from several beds of tuff, and this must be only a fraction of the total number. Volcanic activity must have been tremendous throughout the Sierra Madre Occidental in Tertiary or, at least, post-Cretaceous times, and there was flow after flow of andesite, dacite (?), rhyolite and basalt, together with deposits of corresponding tuffs. About 800 m. below the rim we encountered red rhyolitic tuff, strongly bedded, with strike N. 10° E. (true) and dip 27° E., conformably below which was similar white tuff. The tuff beds were, together with intercalated rhyolite, perhaps 300 m. in thickness. On the farther (northern) side of an arroyo north of these tuff beds and in a

line with their strike there is a massive flow of rhyolite, estimated at 75 m. in thickness, and andesite (?) comes against the rhyolite on the east.

About 850 m. below the pass over the rim of the cañon there is a small mesa almost entirely cut off from the surrounding ridges. This seems to be the remains of an inclosed basin about 350 m. below the level of the large inclosed basin just described. Its upper surface appeared to be composed of basin conglomerate and sandstone. We did not visit it.

Our trail descended the bed of a little stream carved in a bed of andesitic lava at its contact with an underlying bed of decomposed red porphyritic lava. We reached the Aros river about 1225 m. below the pass over the cañon rim. At this point therefore the Aros river is approximately 1340 m. above sea level. At the trail crossing, which is a ford except when the river is in freshet, there is a bed of vesicular basalt (?) the upper surface of which preserves the ropy appearance of a surface flow. The convexity of the "ropes" is toward the south, showing that the direction of the flow was from the north. The bed is now in a horizontal position and there are indications of its being a double flow or even more complex. It is conformably overlain by a reddish yellow, rather soft sandstone about 1.25 m. thick, the thickness changing with the inequalities of the surface on which the deposit was made. It seems reasonable to suppose that the sandstone is a consolidated basin deposit, though it may indeed mark the course of an ancient stream. There is said to be considerable horizontally bedded sandstone in the various cañons and arroyos, but exact data regarding other occurrences are lacking. Above the sandstone at our crossing of the Aros there is a heavy bed of extremely altered vesicular basaltic lava. This bed and that below the sandstone have their vesicles filled in part with altered zeolitic material.

Recapitulating the section exposed in the east wall of the Aros cañon on the Dedrick-Guaynopita trail we have, beginning below: basalt (?) of undetermined thickness, with its surface about 1345 m. above the level of the sea; reddish yellow, soft sandstone, 1.25 m.; massive augite andesite flows, 100 m.; red and white rhyolitic tuffs with intercalated beds of rhyolite, 300 m.; augite andesite with rather coarse-grained groundmass, 180 m.; basin sandstones and conglomerates, 120–140 m.; strongly porphyritic augite andesite with very fine-grained groundmass 50 m.; concealed by wash of gravel and sand, 450 m.; rhyolite (to summit of cordon west of Dedrick) 250 m. This gives a total thickness of about 1,475 meters, but it must be remembered that the determinations were made with an aneroid barometer while passing once over a crooked trail.

We found the Aros river to be in flood, though still 4.5 m. below the highest level for recent years, as recorded on the banks. We roughly

Fig. 1. Aros Cañon.

Dissected inclosed basin near Dedrick. The beds are basin conglomerates and sandstones resting discordantly on andesite flows and tuff beds.

Fig. 2. Aros Cañon.

Near junction with Rio Chico. The great bluff, 220 m. high, shows beds of rhyolite alternating with beds of tuff.

calculated the width of the river at 40–45 m. and the rate of the current at about 100 m. per minute, but about 200 m. below our ferry the banks of the stream contracted considerably and there were dangerous rapids. The stream was much too high for fording, hence we constructed a rude raft with split cedar logs and ropes and transferred ourselves and our baggage safely to the farther side. Before the floods came, a stout rope had been stretched across the river and tied to convenient trees. This rope and a long rope which we had with us gave us the means of pulling our raft from one side of the river to the other with the aid of the swift current. Horses, mules and burros swam the stream without much difficulty.

The Aros cañon is described as beginning about 8 km. N. W. of the little town of Temosachic on the Chihuahua and Pacific railway. The first section of its extremely tortuous course is toward the south for about 40 km. until it receives the important tributary from the southeast known as the Rio Verde, then it turns abruptly through more than 90° and pursues a northwesterly course for about 100 km. to the junction with the Rio Chico, where it bends westward in a grand curve for about 20 km. past Guaynopita and then follows a southerly course again for 50–60 km., receiving on the way the important Tutuaca river from the south-southeast. Near Guadalupe the Aros turns through an angle of 180° and then flows northwest and west to its junction with the Yaqui river, of which it is the chief affluent.

This river system is a most interesting example of a series of consequent streams whose drainage has been captured by a master stream cutting its way backward transversely to the original slopes of the lavas and tuffs making up the main mass of the plateau region. A striking feature of this system is the entrance of most of the tributaries into the Aros in an inverted, *i. e.*, an upstream, sense, or direction. The Aros itself flows southward for several kilometers before its junction with the northflowing Rio Verde, which is the major stream at this point; the Chico flows southward into the northflowing Aros; the northflowing Tutuaca empties into the southflowing Aros; even the minor branches show the same feature and flow in an "upstream" direction into the major branches and the great river.

From the ferry we advanced northwestward down the cañon about 3 km. to a widening of the gorge where we camped upon the surface of the basaltic flow which we encountered at the ferry. The large, perfect and numerous potholes, now 8–10 m. above low water level, testify to long-continued presence of rapids at this point, and there are many such groups along the swift stream. The construction of the trail exposed fresh sur-

faces of the vesicular basalt and the author observed apophyllite, natrolite, calcite and quartz among the minerals filling the vesicles of the old lava. Above this flow there is a heavy bed of well-consolidated basaltic agglomerate or breccia. The hard agglomerate fills the shrinkage fissures in the upper part of the basalt flow. Above the agglomerate there is a heavy bed of andesite.

Above the andesite there occur several beds of rhyolitic lava and tuff. An almost vertical cliff 220 m. high near our camp beside the river showed at least eight beds of rhyolite in its composition. Opposite this great cliff we turned abruptly to the south and climbed rapidly out of the lower portion of the cañon. About 90 m. above the river the trail crosses a dike of rhyolite porphyry cutting through the dark-red, devitrified obsidian or glassy rhyolite forming the country rock. The dike is from 2 to 7.5 m. wide and can be traced readily for about 200 m. in a direction N. 55°–60° W. The dike bifurcates toward the northwest and is lost. Slicken-sided surfaces associated with this dike prove differential movement to have taken place in the country rock. Above the red beds there is a heavy bed of very light-colored, pinkish white rhyolite forming a striking feature of the landscape. The rock is so much like the dike rock just described that it seems probable that they are parts of the same magma, though there seems to be no immediate genetic connection with the dark-red rhyolitic rock.

Pursuing our way up the side arroyo, the grade of which is directly contrary to that of the Aros, we found basin conglomerate and sandstone 140 to 150 m. thick. Above the basin deposits dense and amygdaloidal andesite flows were present from about 1600 m. to 1780 m. above the sea. At 1780 m. we encountered the lower portion of the whitish or light colored rhyolite above referred to, which we found to be not less than 100 m. thick.

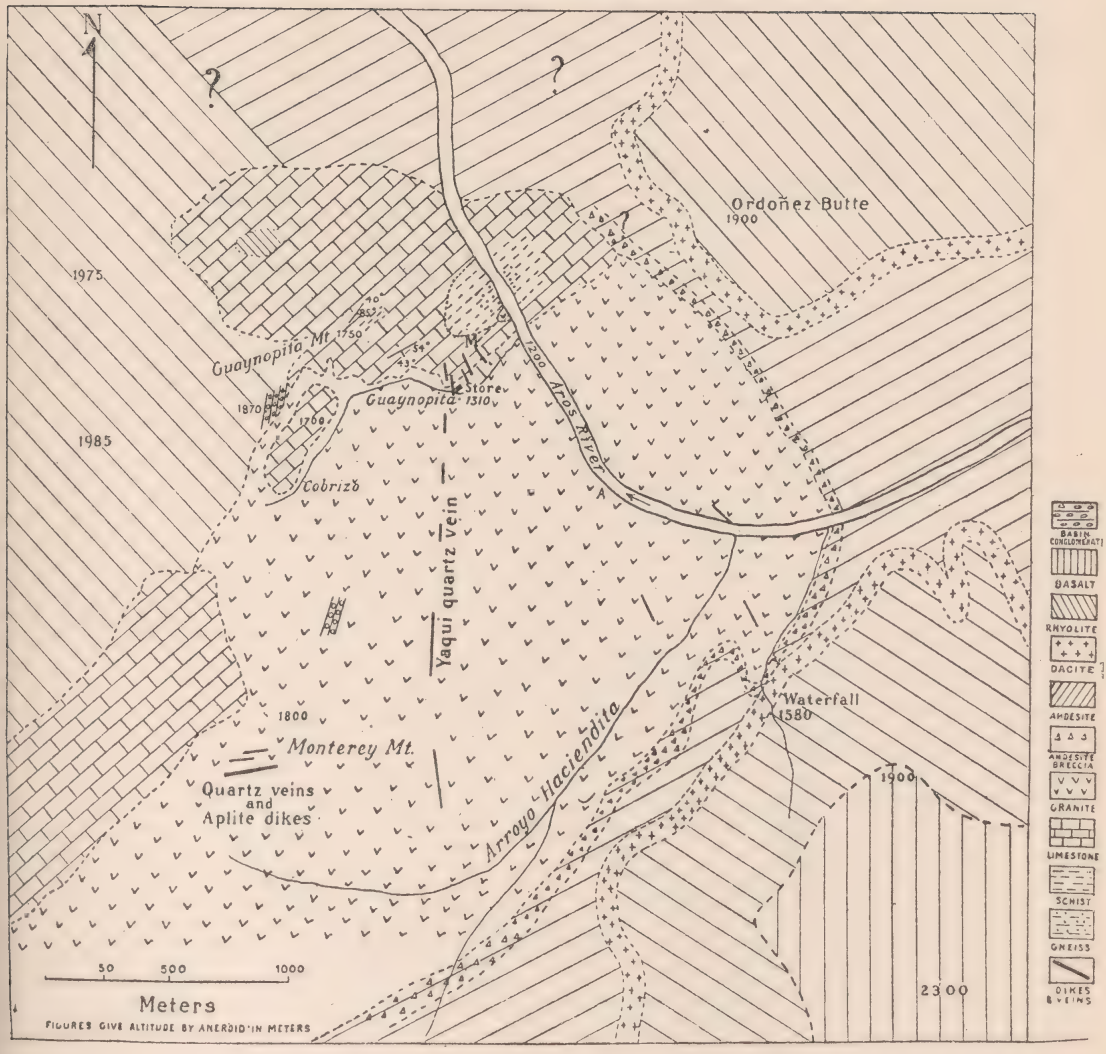
Here the trail drops somewhat into the head of a small arroyo, passes through a grove of large, handsome pines and within two or three hundred meters comes out suddenly upon the point of a salient jutting out into the main cañon of the Aros. My aneroid gave the elevation of the pinnacle as 1780 m. above tide, or about 550 m. above the boiling flood of the river in plain sight below us and apparently almost at our feet. A magnificent scene was spread out before our eyes, as we looked into the maze of cañons and arroyos. The bright reds of some of the rhyolite beds contrasted strongly with the dull reds of others, the light gray or white of the tuffs, the browns of the low-lying andesites, the various greens of grass-grown slopes, live-oak woods and pine forests and the brilliant yellow of an occasional lichen-covered cliff. From this view-point we could look into the upper portions of the great cañon of the Chico river, a tributary of the

FIG. 3

GUAYNOPITA DISTRICT, CHIHUAHUA, MEXICO.

Geology by E.O.HOVEY.

Based on topographic sheet by R.T HILL



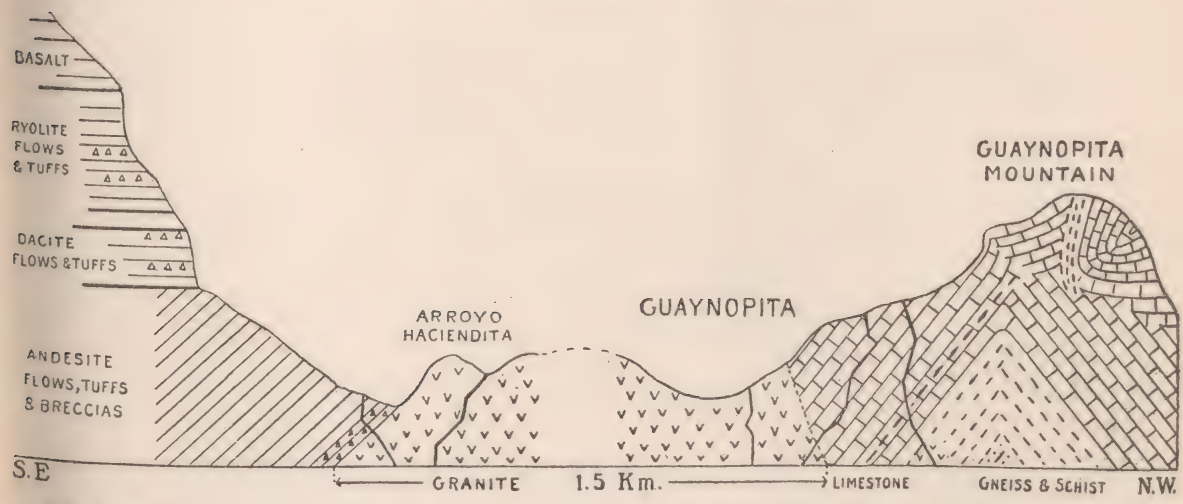


Fig. 4. Idealized section across Guaynopita district from S. E. to N. W. Heavy black lines are diabase porphyrite dikes. Proportions are entirely schematic. Determination of dacite is provisional and should have been so indicated in figure.

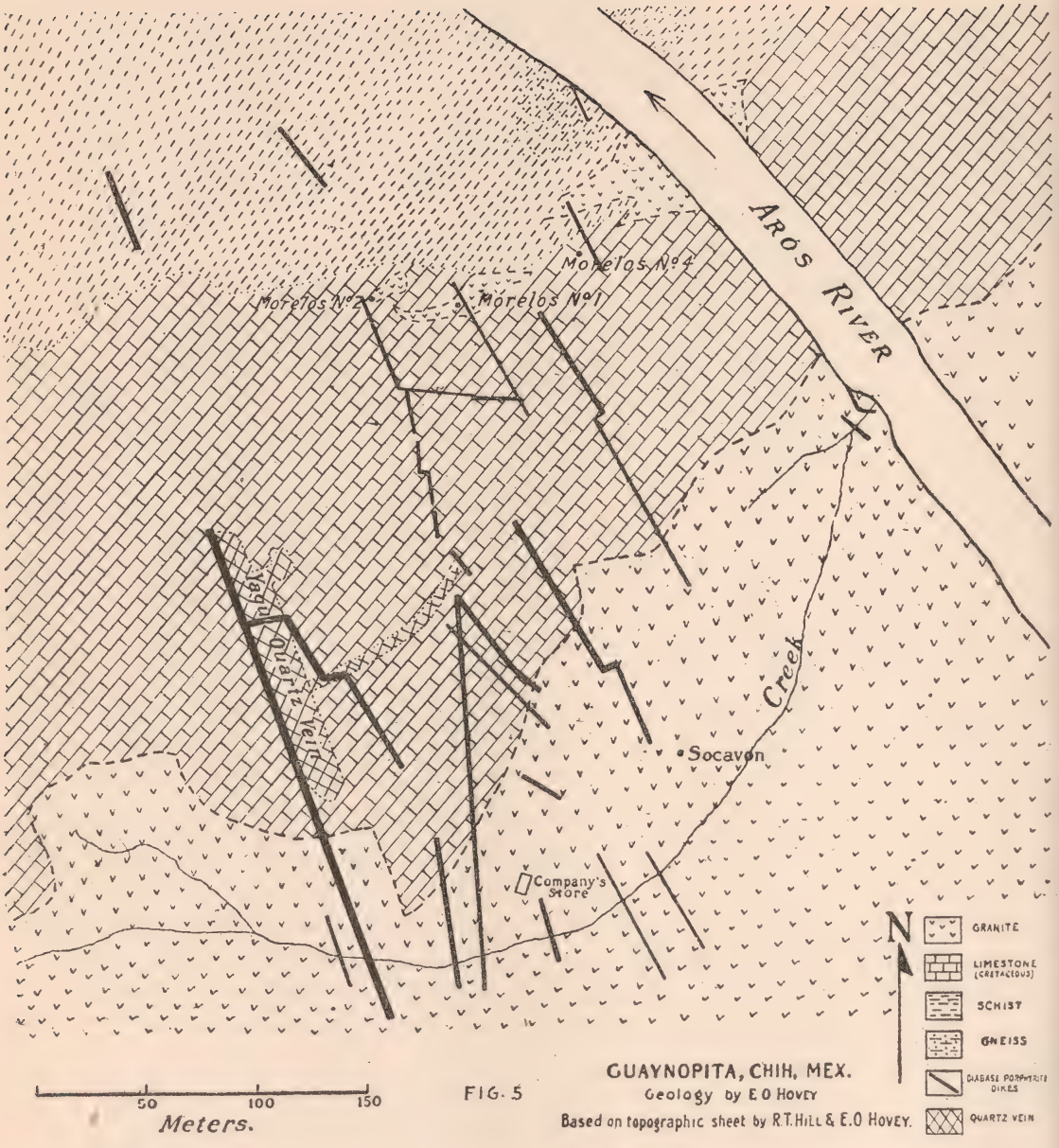


FIG. 5

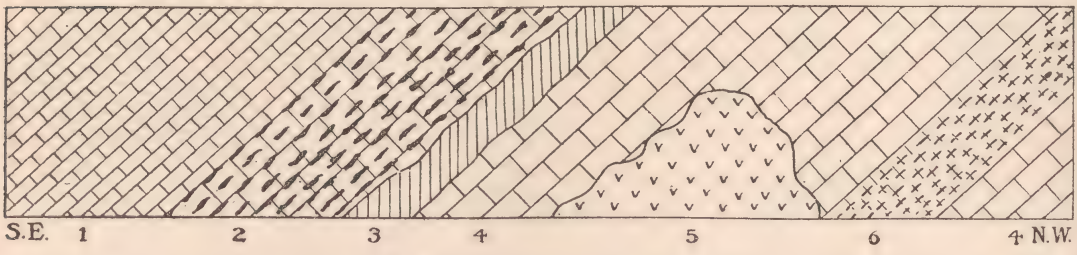


Fig. 6. Section along trail east of Morelos No. 2. tunnel, Guaynopita. Looking S. W. 1. Heavy bedded limestone 25 to 30 m. 2. Heavy bedded limestone, 4 m. thick, containing many bands of chert 10 to 15 cm. thick. 3. Diabase porphyrite dike 1.5 m. thick. 4. Heavy bedded limestone; silicified near the dike. 5. Granite apophysis 9 m. wide at base of section. 6. Calcareous chloritic schists 2.5 m.

Aros, where there are said to be many ruins of pre-Columbian habitations in caves or on vantage points.

The trail winds for nearly a kilometer along the edge of the plateau overlooking the river, and then descends rapidly into the portion of the gorge in which the mining operations of Guaynopita and Monterey are carried on. The Aros cañon widens considerably through the entry of the Arroyo Haciendita and its tributaries from the south together with some other minor affluents of the main stream, but the extent of the little Guaynopita district is comprised within an area scarcely 4 km. square.

The geology of this district has been discussed by the author in another

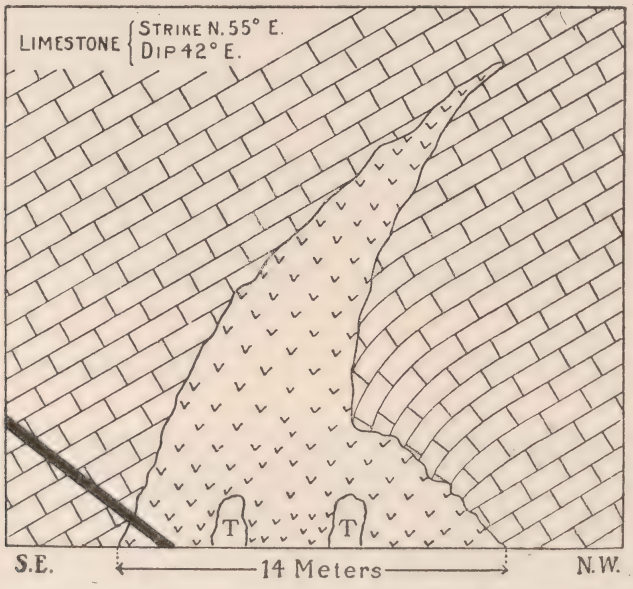


Fig. 7. Granite apophysis in limestone at Morelos No. 1 tunnel (T), Guaynopita. Looking S. 55° W.

place,[1] so that a mere summary of facts and conclusions will be given here. At Guaynopita the Aros River has cut its cañon down into the granite core of the Western Sierra Madre region. The granite, however, is intrusive in and therefore younger than a bluish crystalline and semi-crystalline limestone which is most probably of Cretaceous age (*fide* R. T. Hill), and marine origin.[2] The granite is also younger than andesite flows and breccias (tuffs) which seem to be unconformable with the limestone also. The limestone strikes N. 55° E., has been greatly elevated, tilted, contorted, overthrust, faulted and metamorphosed by the mountain-making forces which have raised the general region, and which here seem to have acted

[1] Festschrift, Harry Rosenbusch, pp. 77–95. Stuttgart, 1906.

[2] The fact of the occurrence of post-Cretaceous intrusive granite in Mexico seems to have been made known first by E. Ordoñez, *Vid.* Bol. Inst. Géol. de Mex., Nos. 4, 5 and 6, p. 76.

from the west. Impure clayey layers within the limestone have been altered by regional metamorphism into schists. Gneiss is closely associated with the schist. Dikes of diabase porphyrite intersect granite and limestone alike, and they also cut across the great quartz veins which traverse the granite and limestone. Above the old andesite there are flows and tuffs of dacite (?), rhyolite and basalt. The order of sequence is, beginning with the oldest rock exposed at Guaynopita, Cretaceous limestone, andesite, granite, quartz veins, diabase porphyrite dikes, dacite (?), rhyolite and latest of all basalt, agreeing essentially with the sequence made out by W. H. Weed for his section across Chihuahua and Sinaloa from Parral to Bacubirito some hundreds of kilometers south of Guaynopita.[1] From the evidence observed in the east side of the Aros cañon and elsewhere the

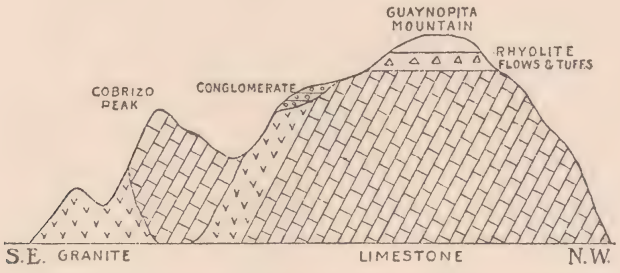


Fig. 8. Section from east to west through Cobrizo Peak and Guaynopita Mountain. The proportions are entirely schematic.

author is obliged to insert younger andesites also among or above the dacite (?) flows and tuffs, and basalts in the older part of the series. Guaynopita mountain is composed mostly of the upturned limestone, upon which the rhyolite seems to lie directly without any intervening andesite or dacite. The granite is a biotite granitite of medium coarseness of grain associated with hornblende granitite and muscovite-biotite granite.

The granite carries chalcopyrite in considerable amount and this has supplied the copper ores (chalcopyrite, tetrahedrite and oxidized ores) to the contact zones and the great veins. The ores carry commercially important values in gold and silver. Contact phenomena are comprised mostly in the serpentinization and marmorosis of the limestone and the garnetizing and epidotizing of the granite. Local enrichment, or secondary concentration, of lead and copper sulphides and oxidized ores has occurred in connection with some of the dikes.

The cañon of the Aros is strongly V-shaped at Guaynopita, evidencing a youthful stage of development. The more rapid cutting done by the great stream is shown by the presence of "hanging valleys" along the sides of the

[1] Trans. Am. Inst. Min. Eng., XXXII, p. 458.

Fig. 1. Aros Cañon at Guaynopita.

Lower part is cut partly through granite. The upper salient at the left is of Cretaceous limestone. Volcanic rocks form the background.

Fig. 2. Aros Cañon at Guaynopita.

Old (left) and new (right) channels of the river in granite.

Fig. 1. Guaynopita. The Cobrizo Peaks.

Outliers of Cretaceous limestone resting upon an intrusive granite. Mineralization has gone forward along the contact zone.

Fig. 2. Guaynopita.

Cretaceous limestone showing an overthrust fault. View looking north-northwest from near the northern (right) of the Cobrizo Peaks as seen in Fig. 1.

Fig. 1. Guaynopita. Ordoñez Butte.

Southwest face showing limestone and associated schist, overlain by volcanic rocks. Intrusive granite is at the bottom of the section.

Fig. 2. Ocampo.

The Santa Juliana vein about 5 meters wide (right half of view) cuts a heavy bed of diabase and its underlying Navosaigame conglomerate.

Fig. 1. Near Guaynopita.
Contact of granite (left) with andesitic breccia. About 1.5 km. east of the mining camp.

Fig. 2. Rancho Las Animas.
Rounded knob of trachyte (left). A brecciated flow.

great gorge, some of which show picturesque waterfalls. High level (550 to 600 m. above the river) benches of conglomerate and sandstone show the former position of some of the basin deposits of the old inclosed basin. Directly across the Aros from Guaynopita a strong butte rises from the river. The point is really an outlier of the Candelaria mountain mass, but it shows so typically the whole important history of Guaynopita and therefore of the Western Sierra Madre that it seems worthy of a definite name, and Professor Hill and the author have taken the liberty of dignifying it by naming it Ordoñez Butte after Ezequiel Ordoñez, the Mexican geologist. The face of the butte is shown in Plate XXV, fig. 1.

Leaving Guaynopita 11 March our trail led us up a steep ascent of nearly 1100 m. to the top of the high mesa (2350 m. A. T.), where we encountered andesite and basalt. Looking backward to the north across the Aros cañon we had an impressive view of the profile of the great cuesta sloping gently at an angle of 3° southeastward from the great mass culminating in the Candelaria peaks. The elevated plateau is indeed the "Mother Range" (Sierra Madre), for most of the present relief of the mountains is due to the extensive erosion that has taken place in the great landmass. Westward of Guaynopita the stage of erosion is more advanced, and the resulting relief is more complex and rugged.

For four days our course lay somewhat east of south along the high mesa, 2200 to 2460 m. above the sea, forming the watershed between the Aros river on the east and the Tutuaca, an important tributary of the Aros, on the west. The general slope of the mesa is gentle toward the south of east, and the eastward slope is much longer than the western. The southward flowing drainage is consequent in character, and as has been intimated above enters the "inverted" stream of the Aros in an upstream sense. The westward slopes are very steep and the meagre inverted drainage is slowly capturing the consequent drainage. The mesa varies greatly in width, from a mere ridge, when the two drainage systems come sharply together, to the broad Mesa Venado which is more than 1.5 km. wide at its widest part. The timber of the high mesa, 2100 m. and higher, is the long-leafed pine, and it is abundant, though the forest is not dense.

The vegetation grows in zones dependent upon the altitude above the sea. The best-marked of these zones are perhaps those of the live-oaks and the pines. The live-oaks flourish between altitudes of about 1220 m. and 1830 m., gradually becoming more scrubby on the higher slopes, where an oak coppice looks like an old New England apple orchard. Between 1800 m. and 2100 m. above the sea the live-oaks give place to the jack pine, while above about 2100 m. the long-leafed pine is in its prime. The full grown pines are 45 to 55 m. high and 1.5 to 2 m. in diameter at the butt.

The lowest branches are often 15 to 18 m. above the ground. The timber of the high mesa is the real incentive for pushing forward the railroads which are trying to make their way from the central plateau down to the Pacific Ocean.

The rock of the surface of the mesa over which we rode for 60 km. or more is mostly of dull brownish andesite, rather than the rhyolite which characterizes most of the Mexican plateau. This andesite contains few phenocrysts and has a very coarse-grained groundmass. It would be classed as an augite andesite. There is much more of this rock in the make-up of the surface of the high plateau in western Chihuahua, than has been supposed; and furthermore the andesite occurs at more than one horizon, as is shown in the section in the Aros Cañon from near Dedrick to the ferry on the trail to Guaynopita and elsewhere.

About 60 km. southeast of Guaynopita we reached the old Chihuahua-Dolores trail. For days we had been traversing the trackless forest, hence the well-worn mule-paths of the old route across the Mesa Venado looked like a great highway. For many years this was the road traversed by the thousands of pack-trains needed for the transportation of supplies from

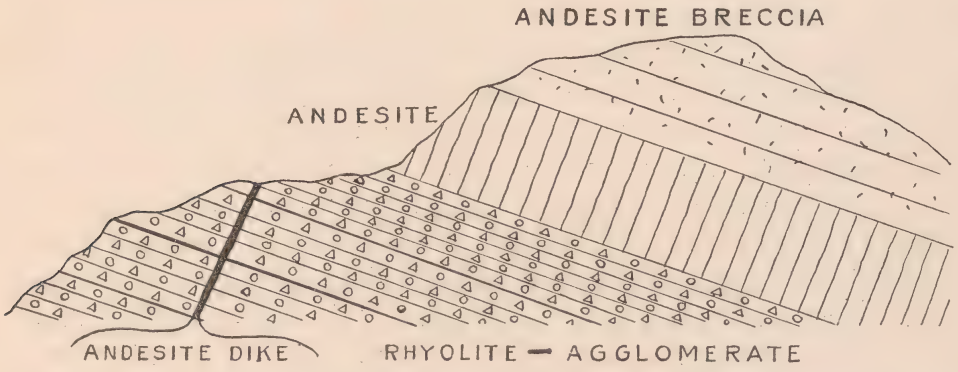
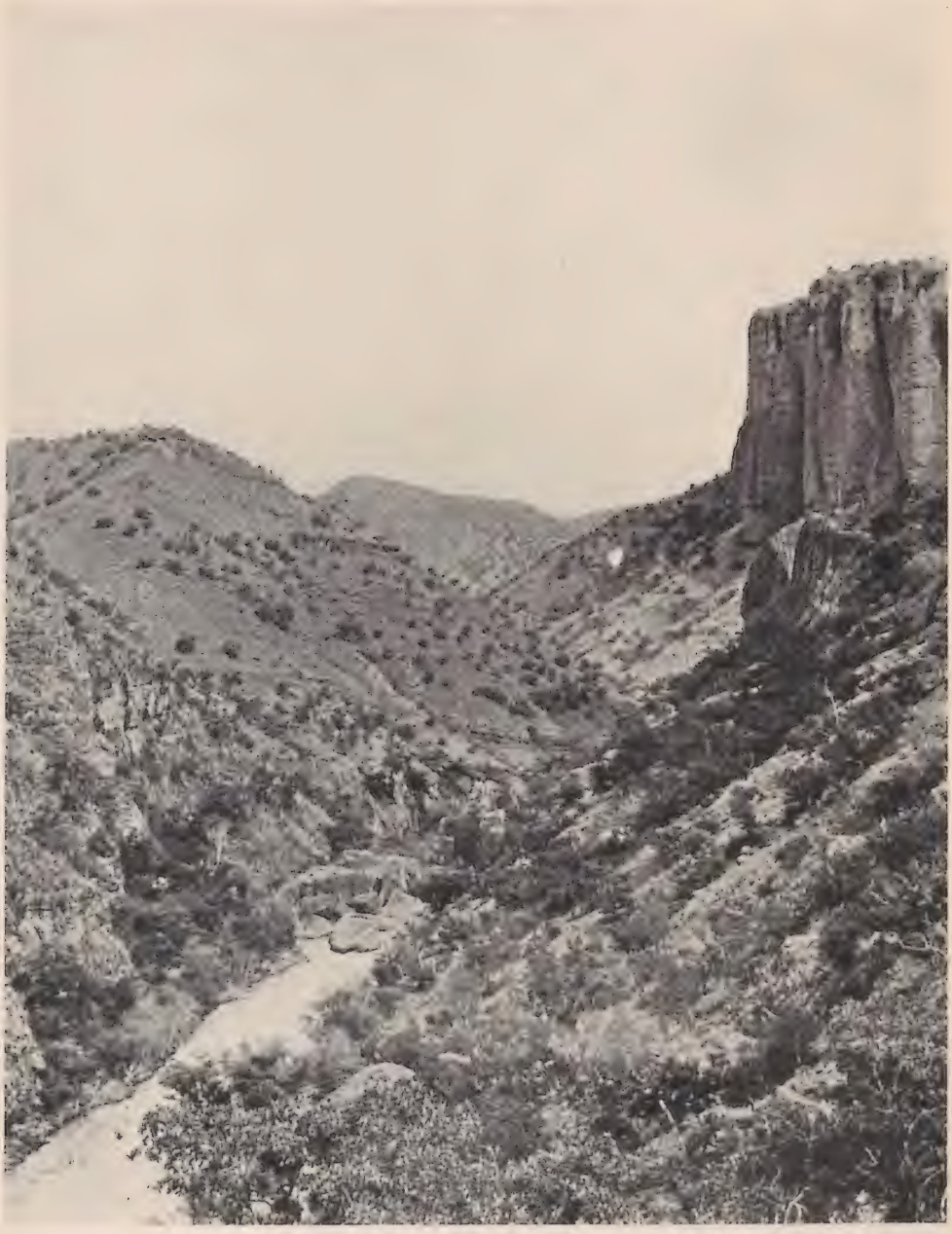


Fig. 9. Arroyo Calaveras in the Tutuaca valley. Heavy bed (150 m. thick) of rhyolite breccia, or agglomerate, cut by an andesite dike and overlain by andesite and andesite breccia.

Chihuahua to Dolores and other mining districts of the Western Sierra Madre and the return of ore and bullion to the capital. Recently, however, a new trail with gentler grades leading to the Chihuahua and Pacific railway at Temosachic has been established south of the Mesa Venado through the enterprise of American capitalists.

Turning abruptly westward from this plateau we plunged into a deep tributary ravine of the Tutuaca river and made a complete cross section of the district included within the Tutuaca cañon to the high mesa west of and above Dolores. The series exposed in the edge of the Mesa Venado was, in descending order: andesite about 80 m., rhyolite 40–50 m., andesite



Tutuaca Cañon, near Dolores.

Lower gorge about 300 m. deep. Basin sandstone and conglomerate in massive formation about 120 m. thick lie upon flows of andesite and basalt.

(dacite ?) 150 m., rhyolitic or dacitic flows and tuffs 200–225 m. Below this series there is lithoidal and glassy rhyolite in massive flows, evidently of great extent, whose thickness could not be determined. Some obsidian was noted. An occasional basic dike is to be seen cutting the lower rhyolite.

We made noon camp on 15 March in Arroyo Calaveras in the midst of the Tutuaca Valley at an altitude of 1520 m. at the foot of a north-facing bluff formed by a heavy bed of extremely coarse rhyolitic agglomerate with gentle dip to the southwest. This agglomerate overlies a flow of rhyolite and is conformably overlain by andesite and a thick bed of andesitic breccia. The rhyolite agglomerate is cut by a strong dike of andesite. North of this noon camp the volcanic beds dip northward and eastward, indicating the probability of the existence of an ancient volcano or at any rate a volcanic vent in the vicinity. (See Fig. 9.)

The lower hills are capped by remnants of basin conglomerates and sandstones, the outliers of the great Mesa San Augustin farther north. This mesa has a gentle dip of 2° to 3° eastward. All stages of the gradual dissection and removal of the basin deposits are to be seen in this section across the Tutuaca cañon, from table-topped mountains, typical "mesas" in the original sense of the word with flat tops many acres in extent, to shaft-like pinnacles upon rounded bases, and even to entirely denuded volcanic mounds, presenting an extremely billowy topography. Approaching the Tutuaca river we descended by an arroyo through these basin deposits and found them about 120 m. thick by aneroid measurement, but the thickness is naturally a variable factor.

The Tutuaca flows northward through the western portion of its drainage basin, with the result that its tributaries coming in from the east are more important than those coming in from the west. This position of the river gives it a particularly thick section through the basin deposits, being near the bordering mountains from which the supply of material came. As we neared these mountains, the component parts of the conglomerate were seen to be coarser. Many boulders 30 cm. or more in diameter of vesicular basalt (andesite ?) and smaller subangular fragments of other lavas were observed in a yellowish or brownish sandy matrix. About 80 m. above the river, *i. e.*, 1190–1230 m. above tide, there is a 40 m. bed of basalt, showing again the unwisdom of laying much stress upon the sequence of the beds of different kinds of lava in a large district. This fresh looking horizontal basalt at Dolores is at the same altitude above the sea as the old, tilted andesite at Guaynopita, only 50 km. distant to the north-northeast. At Guaynopita, on the other hand, basalt is the uppermost rock, 1000 m. higher than this lowest Dolores basalt. Above the basalt at Dolores there

are many beds of less basic lavas, some of them rhyolites, through a vertical section of 1300–1400 m.

About on a level with the basalt flow (1250 m.) the Dolores arroyo cuts through a vertically laminated chloritic schist with northeasterly strike which is evidently a result of extreme regional metamorphism. Time was lacking for the investigation of this exposure, but it should be noted in passing that this zone strikes approximately in the same direction with the zone of metamorphosed rocks (limestones and schists) at Guaynopita, but probably lies somewhat to the east of the axis of that zone.

Following the arroyo upward through the overlying basalt and breccia, at 1460 m. above the sea, or 210 m. above the exposure of schist in the bed of the stream, we came upon the lower portion of the great bed of diabase 140 m. thick in which occur the veins that are being exploited by the mines of the Dolores Company. The veins or dikes cutting the diabase are highly siliceous in character and are strong, wall-like affairs, sometimes 6–8 m. thick, which can be readily distinguished standing above the less resistent country rock north and south of the diabase area. The general course of these veins or dikes is somewhat east of north. They are mineralized with argentite and free gold and silver, and considerable profitable mining was done along some of them in the crude native Mexican fashion before English and American capitalists took hold of the region in systematic manner. Within the mine the diabase becomes more and more fractured and more and more altered and silicified as it approaches the main vein, the "Alma Maria," so that it is not always easy to distinguish the bounding walls of the vein. The zone of fracturing and decomposition may be set down as being 20 to 25 m. wide on either side of the vein, making a total width of 45 to 60 m. including the vein. The alteration of the diabase consists in kaolinizing the feldspar and serpentinizing the augite, resulting in a rock that looks like a porphyrite.

Another series of siliceous dikes forms an extremely interesting feature of the Dolores region. The rock is strongly marked with bright red bands parallel with the walls of the fissure. The rock is a highly acid igneous rock which is to be classed with the rhyolites. The dikes are possibly the feeders of the rhyolite cap which lies over the sheet of diabase. If this be true, the diabase is to be considered an extrusive flow. Direct evidence, however, as to the intrusive or extrusive character of the diabase sheet was not observed. The unaltered diabase showed no special peculiarities. The upper surface of the diabase sheet was determined to be about 1600 m. A. T. Above this is at least 100 m. of rhyolite, including both lithoidal and obsidian flows. These beds have a pronounced dip toward the southwest. They are overlain unconformably by beds of acid tuffs which aggregate 200

Arroyo Dolores and Dolores Mountain.

Strong siliceous veins cut beds of tuff and breccia and are brought into prominence by superior resistance to erosion. Dolores Mountain is about 3,000 m. high and is one of the higher elevations of the Western Sierra Madre.

meters in thickness, the upper portion of which beds shows a dip somewhat north of east.

The journey southward from Dolores was first over the cap of rhyolite flows and tuffs and then southward down a small consequent stream in a broad valley known as the Arroyo Amplio. The stream breaks across the divide on the east and flows in an inverted sense into the Tutuaca. At an altitude of 1800 meters we came to the base of another massive flow of basalt, which proved by aneroid measurement to be 120 meters in thickness. The position of this bed of basalt therefore is the same as that of the rhyolite just mentioned in the Arroyo Dolores, and shows a horizontal alternation between lavas of extreme divergence in chemical composition. This bed of basalt evidently is composed of several flows, since farther south and

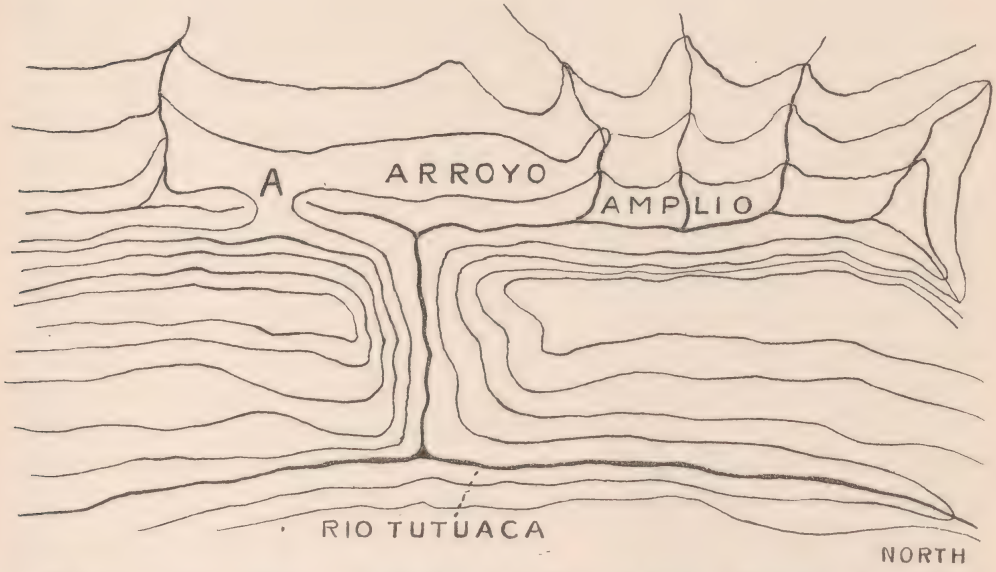


Fig. 10. Arroyo Amplio. A tributary of the Tutuaca south of Dolores. A "wash" of gravel at A has checked the capture of the drainage of the southern part of the arroyo. The sketch lies with north at the right and is about 2 km. from north to south.

apparently continuous with it there are four individual sheets of basalt one above another. The beds dip south of west, or in an opposite direction to those upon the east side of the Tutuaca cañon.

The arroyo here shows considerable stream conglomerate though it may be difficult to distinguish these beds from the basin formations which play such an important part in the eastern portion of the cañon. The stream conglomerate, however, seems to be composed more largely of well-rounded, apparently water-worn pebbles and to be even more local in its development than are the basin formations. The Arroyo Amplio shows high-level terraces of gravel indicating former positions of the stream.

The drainage of the arroyo has been captured by a stream cutting back from the Tutuaca, but a divide of gravel south of the break through the eastern ridge causes the southern part of the arroyo to preserve its consequent southward drainage for a considerable distance farther, until the main stream finally discharges into the Tutuaca and the arroyo comes to an end.

The valley to the west of the Arroyo Amplio is known as the Arroyo Charamusca, in which likewise coarse stream conglomerate and high-level terraces are in evidence. The drainage here too is consequent, *i. e.* toward the south, and like that of the Arroyo Amplio has been captured by the Tutuaca. High up on the western side of the arroyo the rhyolite cap is exposed in several precipitous cliffs 30–40 m. in height one above another with débris slopes between.

The country is intersected with veins of quartz and other minerals, some of which are of great persistence. The largest of these, known as the "Veta Grande," begins about 25 km. south of Dolores in the second north-south arroyo to the west of Arroyo Charamusca. It consists of quartz and calcite somewhat mineralized and rises like a wall above the softer country rock for a distance of 12–15 km. in a north-south direction. Some prospecting has been done on the Veta Grande, but no mining as yet.

Continuing south-southeast from the hamlet of Veta Grande we ascended a long arroyo with inverted (north-flowing) drainage which has been carved out of a tuff bed that dips 15° toward S. 30° W. Our noon camp was made on a bed of vesicular andesite showing beautiful flow structure. This was overlain by the tuff, above which was a flow of basalt lying upon the irregular surface of the tuff. The tuff showed the indurating effects of contact metamorphism for 15 to 20 cm. from the basalt. This arroyo headed abruptly in a cirque-like amphitheatre with extremely steep walls which were hard to scale. The pass between this arroyo and the next longitudinal ravine shows an altitude of 2040 m. (aneroid) above tide. The beds of lava and tuff in the view southward from this divide show the same gentle dip south of west, while those east of the Tutuaca dip toward the east or southeast. Whether this opposition of dip was due to an anticlinal arching of the beds or to the position of original deposition from volcanic vents was not determined, but the uniformity and persistence of the opposing dips would argue for the existence here of a broad, simple anticline with the Tutuaca river flowing near the zone of fracture along a general course about N. 15° W. The surface of the longitudinal (north-south) ridges bordering the arroyos is formed of small, somewhat lenticular mesas diminishing in altitude toward the south. These mesas slope toward the south-southwest in accord with, but to a less degree than, the dip of the component beds of lavas and tuffs.

Our descent to the stream in the next arroyo to the west took us over

four flows of columnar, amygdaloidal basaltic lava with intervening beds of tuff or breccia. The fertile cattle ranch occupying this arroyo is known as Agua Caliente on account of some hot springs occurring here. Two kilometers south of the ranch house there is in the bed of the stream at an altitude 1500 m. a flow of rhyolite overlain by a bed of andesite or basalt.

Three or four kilometers farther south at an altitude of about 1680 m. we came upon the scanty remains of an ancient inclosed basin. The basin sandstone and conglomerate here showed evidence of the presence of water during its deposition in the ancient mud cracks and mud-flat surfaces of the former and the numerous well-rounded (waterworn) basaltic boulders in the latter. Underneath the basin deposits there were, in descending order, basalt, perlitic obsidian and rhyolite. The basin deposits show some remarkable erosion forms in the fragments from the cliffs, but these are surpassed by the erosion of the tuff beds.

The next point of interest was Las Animas ranch about 40 km. due south of Dolores, where a squatter has taken up a little arable land in a creek bottom. The low hills in the vicinity are capped by remains of coarse and fine basin deposits, which overlie tuff beds with a general southwesterly dip. The unconformity between the two is strongly marked. This open swale is limited on the south by a nearly symmetrically rounded dome-like hill composed of breccia made up of large angular blocks of extremely dense, fine-grained trachyte with prominent phenocrysts of biotite and hornblende. The hill is really the northern end of a ridge which stretches away to the south for an undetermined distance. (See Plate XXVI, fig. 2.) The rounded form is due to erosion of the beds, which strike N. 10–15° W. and dip 8–10° W. The "breccia" is composed entirely of angular fragments of solid and platey trachyte in a pasty matrix of the same material and is therefore a brecciated flow. The rock in the fragments is unaltered in appearance and is reddish gray in color on a fresh fracture.

After paying a visit to the Cinco de Abril gold-silver prospect in the Arroyo Colonna (so named on account of the columnar forms left by erosion in a heavy quartz vein), 2 or 3 km. west of Las Animas, we traversed for 3 or 4 km. the Arroyo Largo. Here was probably the most northern exposure of a series of peculiar basins in which the basin sandstones and conglomerates rest upon a heavy bed of almost pure white rhyolite tuff. The basin deposits are harder, or more compact, than the tuff, with the result that the latter has been worn away more rapidly than the former and great fragments of the basin rocks have slid or fallen to lower positions, where they frequently form caps on pedestals of the softer rock. All show the effect of eroding agencies, particularly of wind. In the rather fine-grained, homogeneous white tuff the wind has produced a cornice-like

undercutting at the upper edge beneath the harder basin deposits. The strange effects of this style of erosion were observed from the Arroyo Largo southward for several kilometers through the "Tierra Blanca" district nearly to Yepachic and in other places to the east and south. Besides plain capped pillars there are many masses remotely suggestive of animal forms in their grotesque features of development.

Below the white tuff there is a coarse yellowish rhyolite (?) tuff which is exposed in the lower portions of the Arroyo Largo and again at the southern edge of the Tierra Blanca region where we crossed it. At the latter place the beds of coarse tuff are sharply upturned against a massive bed of hornblende andesite similar in character to the component fragments of the breccia at Las Animas ranch. The strike of these upturned tuff beds is about N. 90° E. and the dip about 45° N., contrasting strongly with the N. 30° W. strike and 10°–15° W. dip of the overlying beds of tuff. It would seem that the position of the tuff beds indicated an intrusive origin for the great bed of andesite, but no contact metamorphism was noted in the con-

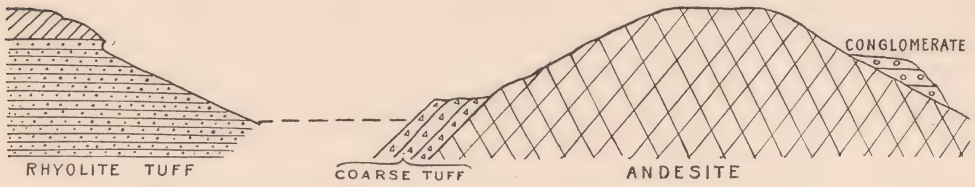


Fig. 11. Section from north to south 4 or 5 km. north of Yepachic showing cornice erosion in fine tuff (see also Plate XXIX, fig. 1) beneath harder basin conglomerate and drag in a coarse yellow tuff upon the surface of a heavy bed of andesite. The conglomerate at the right of the section is a remnant of the old filling of a basin which has been dissected by a tributary of the Mulatos river. The rock lying upon the rhyolite tuff seems to be basin conglomerate.

tiguous tuff, and to assign the local unturning of the beds to drag of the settling tuff strata against the persistent and nonshrinking mass of solid lava seems to accord better with the other facts observed in the region. Under the microscope too flow structure is very pronounced in the groundmass of this rock, — a character unusual in intrusive sheets.

Crossing the mass of andesite at an altitude of about 1850 m. above tide we noticed on the south side coarse well-bedded conglomerate forming a terrace 50–75 m. high above the tributary of the Yepachic river which flows at the base of the bluff. Within a few hundred meters of the andesite bed, and at essentially the same elevation, there is an extensive flow of rhyolite. The section exposed by the river is 60–75 m. thick and shows beds with strong flow structure mingled with those presenting curved columnar parting. The general relations of these rocks is shown in Fig. 11. These horizontal alternations between lavas of greatly varying basicity are of interest in considering the vulcanism of the region.

The little Indian village of Yepachic (2060 m. above tide) straggles along

Fig. 1. "Cornice" Erosion.

In rhyolite tuff near Yepachic under a bed of basin conglomerate. A phenomenon of wind action. See also Fig. 11, p. 430.

Fig. 2. Pinos Altos.

A capped pillar of basin sandstone on rhyolite tuff. Such forms are characteristic of many portions of this part of the Sierra Madre region.

two or three streets on the west side of a fertile inclosed basin, the drainage of which has been captured by the Mulatos river, a tributary of the Aros. The villagers belong for the most part to the Tarahumare tribe. They gain their livelihood by tillage and by caring for pack trains and travelers, the village being located at the junction of important trails through the mountains. The Yepachic basin is bordered by lava flows and tuff beds. Toward the west, beds of red and white tuff with strike of N. 40° E., dip 10° W. are traversed by the trail. The tuffs contain occasional beds of devitrified lava. Looking northward from a point about three miles west of Yepachic we could see tuff (?) beds in the western face of the Santa Barbara ridge with distinct dip toward the east. Such variable dips are to be expected of course in beds of fine volcanic ejecta. The Sierra de Santa Barbara bounds upon the east the valley of the Mulatos river, which is an important tributary of the Aros.

The general aspect of the topography of the head-waters of the Mulatos river system is one of greater maturity than that shown in the Tutuaca basin. Mesas are conspicuous by their absence and buttes with sharp or rounded tops rising to a general level are the present indication of the former extent of original and secondary flat lands. Cañons with precipitous walls seem to be lacking, their places being taken by valleys with more sloping sides, though still with V-shaped cross-section.

Four or five miles west of Yepachic we traversed the picturesque Arroyo de la Cueva, the course of which is east and west. Here we found evenly bedded sandstones at least 150 m. thick with strike about N. 60° E. and dip 20° E. The rock is composed entirely of volcanic materials considerably decomposed. Many of the little pebbles in the gravelly layers are distinctly water-worn in appearance. In color the rock is white, red, yellow and pistach green. In spite of its thickness this sandstone seems to be of rather local development, and on the south side of the arroyo within a quarter of a mile west of the greatest thickness of the sandstone there is a heavy bed of rhyolite. It is probable that the sandstone overlies the rhyolite, but the relation of the two formations was not determined.

Passing to the south over a low divide showing white tuff (or the sandstone?) upon the rhyolite, we entered the Arroyo San José, another east and west ravine. We found ourselves entering a mineralized belt. The walls of the arroyo are of rhyolite flows and tuffs intersected by strong veins of quartz, which are prominent features of the country on account of their superior resistance to disintegration from weathering. In this arroyo is the producing gold mine called "Dios te guie"; at the mouth of the branch arroyo leading down from Cerro Boludo we saw the ruins of a Mexican 5-stamp mill with its arrastre.

Cerro Boludo (or "Bald Mountain") is a residuary mountain composed of rhyolite and andesite flows and tuffs, capped with a bed of reddish white rhyolite 50–60 m. thick which dips gently toward the north. Its top is at an altitude of about 2400 m. above the sea. A mineralized vein, or aggregation of veins, of white quartz 17–19 m. thick cuts through the mountain from west to east (course N. 80°–90° E.) and has been greatly instrumental in preserving the eminence. It is reported to have been traced across country for 8 or 10 km. The vein is much brecciated and contains many cavities lined with drusy quartz crystals. Seams of kaolin, some of which are beautifully slickensided, occur in the vein and show that some differential movement has taken place since the filling of the fissure.

Continuing southward from Cerro Boludo we traversed the Arroyo San Francisco in which at about 1760 m. above the sea lies the small Mexican mining camp of the same name with its little two-stamp mill and primitive arrastre. Gold-bearing quartz carrying copper and nickel is treated here. A great bed of lithoidal rhyolite characterizes this arroyo, giving great bluffs forming the walls of the ravine in places. This arroyo is tributary to the Rio de Mayo. The trail to Ocampo (Jesus Maria) leads out of this arroyo over a divide 280 m. above the San Francisco camp, drops into the small well-wooded Arroyo Paragatos, which joins the San Francisco a few miles to the west, and then passes over another divide into the great cañon of the Rio de Moris, which is the principal tributary of the Rio de Mayo.

The country rock of the upper portion of the great Moris cañon is rhyolite and rhyolitic tuff intersected by many basic dikes. Below this (at about 1900 m. above tide) lies an enormous thickness of dark blue or bluish-green coarse conglomerate which is likewise cut by many dikes, some basic and some apparently acid (rhyolitic). With this conglomerate, or rather alternating with the beds thereof, are associated beds of whitish, finer-grained, hard conglomerate and beds of dark red sandstone. All of these beds seem to be composed entirely of materials of originally igneous origin. Where the trail from San Francisco to Ocampo (Jesus Maria) crosses the Moris cañon the beds dip rather gently toward the east or northeast, but looking toward the west down the cañon one could see the dip gradually diminishing and finally becoming distinctly westerly. The thickness of the detrital beds was not determined for lack of time, but it must be measured in scores of meters even when considerable allowance for possible faulting has been made. The rhyolite forming the cap-rock of the cañon walls was poured out on the eroded upturned edges of the beds of sandstone and conglomerate. This sedimentary series seems to be of sufficient importance to require special designation, and Professor

Fig. 1. Cerro Boludo, near Yepachic.

From the southwest. Altitude 2150 m. above tide. An erosion remnant of indurated rhyolite tuff traversed by a great quartz vein.

Fig. 2. Cañon of the Rio de Moris, 1,200 m. deep.

Rancho Navosaigame. Lower part of gorge is in the dark-blue coarse conglomerate called the Navosaigame formation; upper part is in andesite, rhyolite tuff and rhyolite.

Hill and the author[1] have proposed to call it the Navosaigame formation, for convenience, from the name of the ranch in the Moris cañon where it is typically developed and where we first observed it. Plate XXX, fig. 2 gives a view of the entire northern slope of the Cañon of the Rio de Moris at the Hacienda Navosaigame. The Navosaigame beds are exposed at Ocampo (see pp. 434 and 435) and Pinos Altos (pp. 436 and 439), according to the author's observations, and probably elsewhere. They underlie an area, therefore, more than 20 km. in diameter.

No limestone boulders were seen in the Navosaigame beds, but exhaustive examination could not be made. In the south wall of the Moris cañon opposite the hacienda house a great dike of basic igneous rock rises far into the Navosaigame and may penetrate it. The rock appears to be diabase, but is too much decomposed for satisfactory determination. About 2 km. east of this dike a porphyrite dike with large square or rectangular phenocrysts of feldspar cuts the Navosaigame beds and rises through the caprock of white rhyolite. Here again as usual the basic rock has suffered decomposition to a much greater degree than the more acid lavas. Siliceous veins, however, are not lacking from the region, and a noteworthy example of one crosses the Moris cañon like a great pinnacled wall about 3 km. east of the Hacienda Navosaigame. In appearance from a distance this vein was like the Yaqui vein at Guaynopita, the Veta Grande south of Dolores, the Veta Colonna at the mine "Cinco de Abril" west of the ranch Las Animas, and several great veins at Pinos Altos, besides doubtless many others.

In this region the Moris cañon is not less than 13 km. wide and 1200 m. deep. No basin conglomerates or sandstones were seen, this part of the cañon lying in the zone of more advanced erosion than the district farther east, but river gravels were observed at several altitudes. These gravels contain an occasional pebble or boulder of the blue Cretaceous limestone, evidencing the occurrence of this rock *in situ* farther to the east (upstream).

The trail from Hacienda Navosaigame to Ocampo leads over the Cumbre Potrero at an altitude of 2120 m. above the sea into the Arroyo Rosario which is a tributary of the great Candameña cañon, in another branch of which lies the town of Ocampo. The cap rock of the Cumbre is rhyolite in great development, about 340 m. of the rock by aneroid measurement lying in practical horizontality upon the eroded upturned edges of the beds of the Navosaigame formation. The highest points rise to an altitude of 2320 m. above the sea, or 200 m. above the trail crossing of the old Combre Potrero.

The rocks exposed along the trail in the Arroyo Rosario are decom-

[1] Hovey, E. O. The Western Sierra Madre of the State of Chihuahua, Mexico. Bull. Am. Geog. Soc., Vol. 37, p. 539. Sept., 1905.

posed rhyolitic tuffs and flows lying unconformably upon the beds of the Navosaigame formation, which dip rather gently (about 15°) toward the southeast. Many large and small dikes of apparently rather basic igneous rock intersect both the Navosaigame and the overlying rhyolitic beds. Well-rounded boulders of disintegration are abundant and no fresh rock was seen.

After passing over another divide at an elevation of about 2130 m. above the sea, the trail descends rapidly into the branch of the Candemeña cañon in which Ocampo is situated. Ocampo is a celebrated mining camp, better known, perhaps, by its old name of Jesus Maria. Several mines are, or have been, in operation here, and from one of them alone, the Santa Juliana, more than $100,000,000 worth of silver bullion was taken by its owners during about fifty years of active work in the nineteenth century. The cañon is so deep, narrow and crooked that one does not see the town resting in its bottom, a kilometer below the rim, until he is fairly upon it. The population of Ocampo varies greatly with the prosperity or adversity of the mines, but it is said to average 5,000 inhabitants. It is hard, however, to see where so many people can be stowed away in the dwellings which are in sight, even with the crowding common among the Mexican peons. The town lies at an altitude (Balvanera Mining Co's. office) of about 1800 m. above the sea. Its position according to Lieut. H. O. Flipper, manager of the mines at the time of our visit, is lat. 28° 12′ N. and long. 107° 6′ 40″ W. (Greenwich).

The Santa Juliana mine may be taken as typical of all the mines at Ocampo. A great composite quartz vein 5 to 10 m. thick cuts almost vertically (hade 4° or 5° toward N. W.) through a heavy bed of diabase and the underlying conglomerate (Navosaigame). The contact between the diabase and the conglomerate is exposed in and beside the Providencia tunnel. The quartz is of course entirely secondary in origin and together with its mineral contents seems to have been derived from below. Where the Providencia tunnel enters the bluff the Santa Juliana vein strikes N. 50° E., but about 61 m. from the mouth the vein and, consequently, the tunnel turn more to the north. Plate XXV, fig. 2, shows the relation of the great quartz vein, known locally as the Santa Juliana vein, to the inclosing diabase at the Providencia tunnel. At the lower left hand corner of the photograph the conglomerate of the Navosaigame formation comes into view. The Rincon tunnel, which is near by, follows a thick secondary quartz vein that lies nearly at right angles to the southern (Providencia) end of the Santa Juliana vein and hades strongly (30°) toward the southwest. Other heavy quartz veins in the district run parallel to and at considerable angles with the Santa Juliana. Time was lacking for an in-

Ocampo. Cañon below town.

Navosaigame conglomerate overlain by diabase, above which are andesite and rhyolite flows and tuffs.

Ocampo: Arroyo San Juan.

Cliffs of rhyolite tuff showing effects of wind erosion.

vestigation as to any system upon which the veins and joints might be arranged.

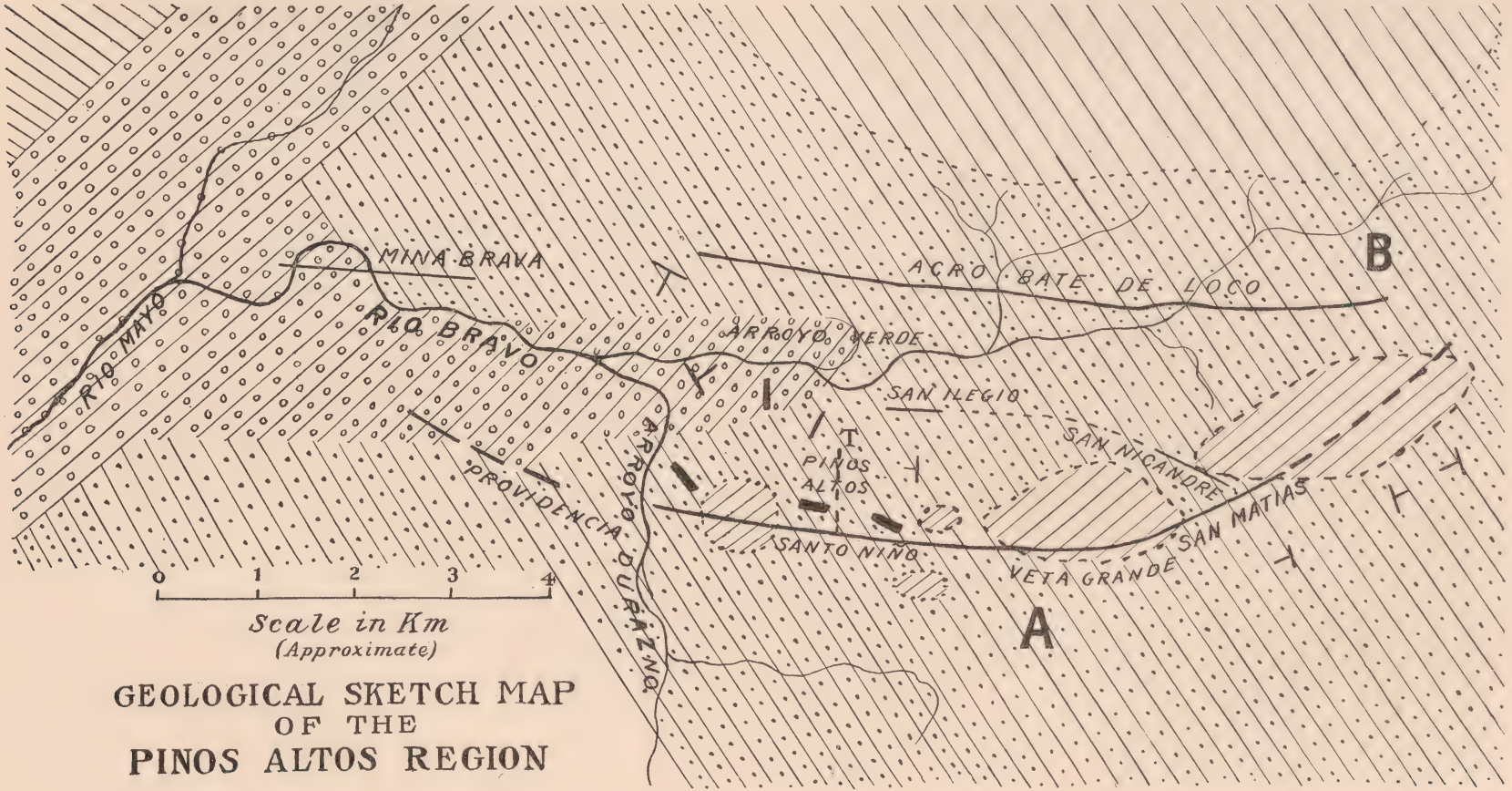
The diabase has highly baked the conglomerate beneath it for 0.60 to 1.2 m. from the plane of contact. The principal effects of the metamorphism are: the change of color to dark purple and the production of a shaly and hackly structure with consequent obliteration of the bedding planes. In places the sandstone or conglomerate has been rolled up into the base of the diabase sheet for several inches or even a foot (30 cm.) from the contact. The extrusive character of the diabase is further indicated macroscopically by the occurrence of an occasional scoriaceous mass in it near the lower contact. Such a mass is a fragment of the original upper or front crust of the stream which has been rolled over to the under portion of the stream. Along the planes of incipient cracks or joints in the diabase and at uniform distances therefrom hematite has segregated, producing narrow zones of red which traverse the rock interruptedly in every direction. Similar zones of hematite occur in the Triassic diabase near New Brunswick, N. J. (and probably at many other localities). The Ocampo diabase shows a beautiful variolitic facies, the spots often being 1.25 cm. or more in diameter and being scattered profusely through the rock. They are darker in color than the groundmass.

Microscopically the diabase presents no peculiarities.

Leaving Ocampo for Pinos Altos one traverses first the Arroyo San Juan in a northeasterly direction, following the Ocampo-Miñaca trail for 4 to 4.5 km. to the "combre" or divide 740 m. above the plaza of the town, where the two trails part company. An approximate section along this arroyo gives, in descending order:

Rhyolite flows and tuffs probably 200 m. thick or more.
Andesitic tuffs and flows (to divide) 160 m. and more.
Coarse, dark-red, cross-bedded conglomerate and sandstone (dip E.), 80 m.
Diabase, 120 m.
Andesite flows, 20 m.
Rhyolite tuffs and flows, 140 m.
Gray conglomerate and dark, thin-bedded sandstone (tuff ?) (dip E.), 55 m.
Diabase-agglomerate, 15 m.
Diabase sheet or sheets, 150 m.
Navosaigame conglomerate at 1800 m. above the sea and below.

The section shows at least three horizons of heavy-bedded conglomerates and coarse sandstones, all dipping eastward or southeastward and covered unconformably by lava flows and tuffs. The fragmental rocks seem to be composed entirely of volcanic materials. The presence of numerous rounded boulders was the feature relied upon to distinguish them from tuffs. To this feature, in the case of the upper sandstone member, was added marked cross-bedding. Pending further investigation these beds



GEOLOGICAL SKETCH MAP
OF THE
PINOS ALTOS REGION

RHYOLITE
RHYOLITE TUFF
ANDESITE
NAVOSAIGAME CONGLOMERATE
VEINS & DIKES
T = Mouth of Tunnel

FIG. 12

Fig. 1. Pinos Altos. North wall of Arroyo Verde.

Navosaigame beds at bottom with interbedded diabase. Lying unconformably upon the Navosaigame are beds of rhyolite tuff, above which is a heavy bed of rhyolite.

Fig. 2. Pinos Altos.

San Ilegio vein, or zone, of quartz with associated silicified country rock. The softer including rhyolite tuff has been removed by erosion.

are taken to be of rather local development and not necessarily a proof of extensive subsidence and re-elevation.

Pinos Altos is a mining town lying 15 or 16 km. north-northeast of Ocampo. The intervening country shows andesite and rhyolite flows and tuffs as the surface rocks. About half-way between the towns there is an area of yellowish sandstone dipping rather moderately south of east. The gently incised plateau which the trail traverses slopes gradually toward the north. Heavy forests of hemlock and pine characterize the region. Pinos Altos lies in the more rugged and deeply cut portion of the plateau between the Arroyo Durazno and the Arroyo Verde near where they join to form the great cañon of the Rio Bravo. The Bravo joins with the Concheña to form the Rio de Moris.

The region has derived its importance as a mining district from a network of strong silicious veins and silicified zones which intersects a complex consisting of basic igneous (probably diabase) dikes and sheets, andesite flows or sheets, acid igneous (rhyolitic) flows and tuffs and a basal conglomerate composed of water-worn igneous materials. Being little known, the district merits rather extended descriptions on account of its interesting features.

The strongest veins, or silicified zones, are three in number and run in a general easterly and westerly direction. They are the Mina Brava and its probable extension the Acrobate de Loco, north of the Rio Bravo and the Arroyo Verde; the San Ilegio and its continuation the San Nicandre in and near the southern wall of the Arroyo Verde, while farther south is the largest vein of all, which is known in its different parts from west to east as the Providencia, the Santo Niño, the Veta Grande and the San Matias. There are many trans-

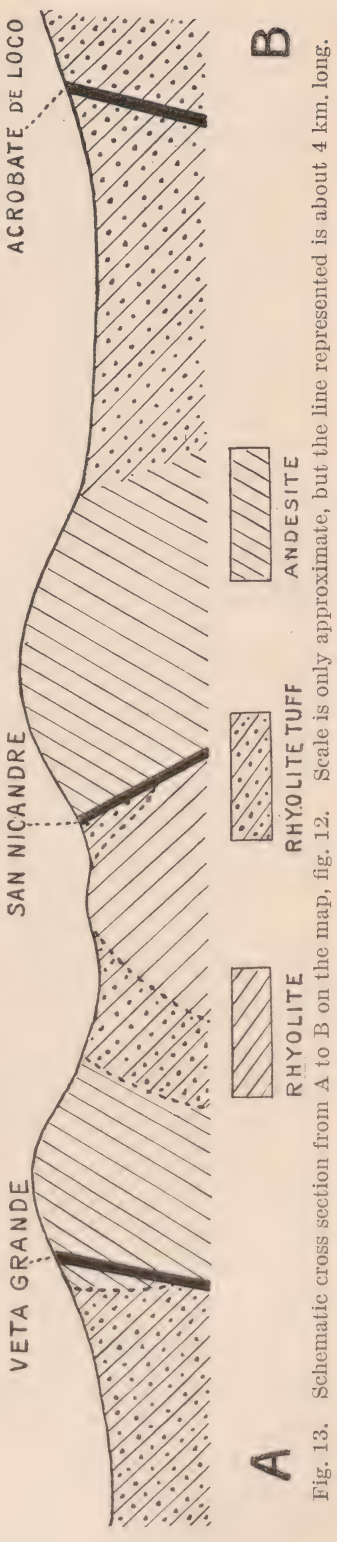


Fig. 13. Schematic cross section from A to B on the map, fig. 12. Scale is only approximate, but the line represented is about 4 km. long.

verse veins of small size which, however, seem to have had an important bearing upon the mineralization of the region. The largest of these cross veins is the Transvaal, 1.5–2 km. northeast of the Mina Brava. The relation of the principal veins to one another and to the country rock is indicated on the accompanying sketch map (Fig. 12), important data for which were supplied by Mr. R. S. Brooks, a mining engineer in the field who was thoroughly familiar with the district. The author did not visit the veins north of the Arroyo Verde.

At several points the veins, or zones, are prominent features of the landscape on account of their superior resistance to the subaërial erosion which has cut deeply into the associated tuffs. The action of the erosive agencies has been much quickened during recent years by the removal for mine timbers of the "lofty pines" which gave the district its name. All the veins are alike and therefore a description of the Santa Niño will suffice for all. This vein has been exploited by the workings of the Pinos Altos Mining Company and access to it 400 m. below the surface is easy by the main mine tunnel, which is 1050 m. long, entering from the south wall of the Arroyo Verde. The rock through which the tunnel has been driven is entirely rhyolite tuff, with three or four quartz veins about 1 m. wide and several silicified zones. The Santo Niño vein is considered to be from 10 to 15 m. wide, and much drifting and stoping has been done upon it. It is reported that at the point of intersection of the tunnel with the vein the ore ran about $4 in gold per ton.

The so-called "vein" does not have well-defined walls, and it seems to be a closely set network or zone of veins rather than a single vein. The amount of sulphide ores (pyrite and chalcopyrite) present gradually diminishes with distance from the most definite siliceous vein. The diminution is probably secondary and due to the oxidation of the pyrites. Fractures abound in the immediate country rock, which is an indurated (silicified) rhyolite tuff, and slickensided surfaces show that differential movement has taken place within the mass. Ferruginous brecciated zones occur in the tuff beside some of the smaller quartz veins composing the Santo Niño network. The veins are essentially vertical in position and intersect the whole series of rocks exposed, with the possible exception of the highest cap-rock of rhyolite, which is exposed only north of Arroyo Verde.

Examination of the country rock westward of the mine tunnel (at T on the map, fig. 12) as far as the Arroyo Durazno shows that beds of highly inclined (strike, N. 20° W., dip 35° E.) dark-blue and dark-red conglomerate and sandstone underlie discordantly the partly silicified rhyolite and tuff in which the mine occurs. A long period of erosion occurred after the tilting of the conglomerate-and-sandstone beds before the deposition of the tuff

beds. The materials making up the conglomerate and sandstone seem to have been derived entirely from ancient basic igneous rocks, and the beds are referred to the Navosaigame formation. Interbedded with the conglomerate are beds of diabase, and diabase dikes intersect the stratified rock and the overlying rhyolite tuff. The baking effect of contact metamorphism is more evident perhaps in the beds of rhyolite tuff than in the Navosaigame conglomerate. The passage of these basic dikes through the rhyolite tuff as well as the Navosaigame indicates the probability that the intercalated diabase sheets in the latter are intrusive in character, and that they were subsequent in origin to the tilting of the conglomerate. In the north wall of the Arroyo Verde a heavy bed of rhyolite lies upon the tuff beds.

The region is one favorable to mineralization. Early igneous activity, during which rather basic rocks were produced, was followed by quiet times when the dark blue Navosaigame conglomerate was laid down, possibly in inland basins formed after the manner of the present mesas of the country. Then followed some regional deformation, as is shown by the rather high dip of the conglomerate. This period of deformation was followed by one of renewed activity, resulting in the outpouring of great quantities of rhyolitic lavas and the ejection of accompanying ashes. The ash formed the major portion of the ejecta, and it now shows strong stratification. The general dip of the ash beds is about 10° W. by S., but there are many variations. After the eruptions of acid materials came the intrusion and possible outpour of andesitic and even diabasic lavas.

The nature of the region between Pinos Altos and Miñaca can be described in only the most casual manner, since the 115 to 130 km. of trail were passed over in about two days of travel. The trail first passes over a great area of the yellowish, reddish and whitish rhyolite tuff. Nine kilometers from Pinos Altos near the road to Concheño there is a stream half a kilometer across of rhyolite showing flow structure beautifully and associated with much perlitic obsidian.

The trail keeps for the most part on the areas of tuff, but occasionally traverses a gorge in a flow of rhyolite or crosses the surface of an area of andesite. About 40 km. east of Pinos Altos the trail drops into a vertical-walled gorge perhaps 50 or 60 m. deep in sandstone. The beds seem to be horizontal in position; they contain rounded grains and pebbles, and they show some cross-bedding. This probably is a strong development of basin sandstone. In color the rock is light yellow or whitish, but red pebbles were observed. The erosion phenomena shown in the gorge just mentioned are remarkable, and the numerous pinnacles, crags, grottoes and archways which have been carved out of the rather soft material make the views in

every direction most picturesque. The hour of my visit was so late that I could not stop to examine the rock closely or take photographs.

The little Indian (Tarahumare) hamlet of La Cueva Humada is in the midst of this area of sandstone and is about 12 km. west of the village of Temochic. The Temochic river, a tributary of the Rio Verde and thus of the Aros, traverses the sandstone area from southwest to northeast and is bordered by vertical cliffs of the rock 40 or 50 m. high. In the near distance can be seen the mountains of andesite and rhyolite that inclose the sandstone.

The regularity of the sandstone beds is sharply disturbed near the river 3 km. west of the village of Temochic. The beds on both sides of the Temochic river suddenly turn sharply upward, changing within a few yards from a horizontal position to a dip of 30° or more toward the W. N. W. on the west side of the river and toward the opposite direction on the other side. The disturbing factor was probably an igneous intrusion, but the question could not be investigated on account of a heavy snowstorm that was raging at the time of my visit.

The Tarahumare village of Temochic lies in a typical inclosed basin six or eight kilometers in diameter, the drainage of which has been captured by the Aros drainage system. The elevation of the village as determined by aneroid, average of two readings, is 2110 m. above the sea. East of this basin the trail rises over an extensive flow of andesitic lava, reaching an altitude of 2310 m. upon it. At La Junta, 12 km. east of Tomochic, basalt is encountered at 2200 m. above the sea. Three kilometers beyond La Junta the Rio Verde, which flows northward into the Aros, cuts down to 2150 m. A. T. in this sheet of basalt, and east of the river the trail rises to 2340 m. on the basalt, giving a thickness of at least 190 m. for this flow or series of flows. The basalt apparently covers an area of many square kilometers and dips gently toward the west. It has been considerably dissected by the Rio Verde and its tributaries.

The eastern limit of this basalt plateau is sharply defined near a little hamlet called Agua Caliente about 18 km. east of Tomochic. The bottom of the valley here is 2160 m. above tide and the section shows basalt, rhyolite and obsidian (bed 30 m. thick), andesite tuff and andesite in descending order from the west. East of Agua Caliente the trail rises rapidly again to the top of a basalt plateau, which may well be part of that to the west of the hamlet. After quickly regaining the altitude of 2360 m., the trail crosses for 6 or 7 km. an almost uniform slope of basaltic lava, some of which is scoriaceous, which gradually rises to the altitude of 2420 m., at its eastern border. This plateau or part of the great plateau, extends for many kilometers north and south. It has not suffered dissection to the extent shown

Miñaca Basin.

A great inclosed basin the drainage of which has been partly captured by the Aros river. Shallow depressions retain ponds in varying stages of desiccation.

MIÑACA BUTTE.

Remnant of an andesite flow, illustrating the process of filling inclosed basins through disintegration of rock beds and the transportation and distribution of the resulting fragments.

by that portion west of the Rio Verde, thus maintaining the observation made farther north that erosion is advancing from the west eastward. The great basalt mesa, or plateau, is bounded on the east by a strong, deeply serrated cordon rising 300 or 350 m. above it and extending in a general N. N. W.–S. S. E. direction. The trail crosses the cordon through a notch at an altitude of 2510 m. above tide. The material of the cordon is augite andesite, dark purplish gray in color, weathering to a deep red.

The descent to the basin east of the great cordon is rather gradual, and the floor of the basin may be said to begin at an altitude of 2300 m. It continues to descend more gently for two or three kilometers from the western edge, when the barometer reads about 100 m. less, and this (2200 m. A. T.) is essentially the level of the broad flat plain forming the bottom of the basin. The basin is one of the largest encountered upon the route described in this paper, being 15 to 18 km. wide from east to west and 35 to 40 km. long. In the middle of it on the Aros river lies the old Tarahumare village of Pahuirachic, not more than 2 km. distant from the new railroad town of Miñaca, which at the time of my visit was the passenger terminus of the Chihuahua and Pacific railway toward the west.

The basin contains many lagunas, large and small, some of which appear to be permanent in character, while most are periodic. Much of the drainage is still internal, although the Rio Aros (here called the Rio Guerrero) has made its way completely across the area. Here and there is to be seen the top of an almost buried mountain. Most of these knolls are of rhyolite, some are of andesite, some of trachyte and those of basalt are not absent.

About 1.5 km. east of Miñaca the peculiar hill known as Miñaca Butte rises 200 m. above the level of the plain. The eminence receives its name from the Mexican hero, General Miñaca, who lies buried on the top, having been killed there with his followers while making a stand against the attacks of hostile Indians.

The Butte is a double cone (a small steep one upon a broad low one), the residue of a sheet of extremely glassy biotite-andesite. Devitrification and weathering have gone so far as greatly to obscure the microscopic characters of the rock. The upper and more glassy portion of the hill is decidedly more columnar in structure than is the lower, while in the lower part the bedding is more pronounced. The less glassy lower part of the hill has resisted disintegration more successfully than the upper. The whole process of disintegration and consequent basin filling is beautifully shown from the columnar structure and horizontal jointing due to contraction from cooling, through the great subangular blocks and the smaller rounded masses, boulders, pebbles and sand to the fine soil of the plain, resulting from the constantly acting strains arising from diurnal and secular variations in temperature.

About 2 km. south of the railway station at Miñaca a group of low knolls marks the top of a buried mountain of andesite. Black glassy lava occurs around the outside of the circle, the rock being rather dense, with flattened vesicles. Within this zone is a zone of cryptocrystalline andesite with strongly marked platey parting, while the center of the group is of fine-grained dark-gray rock. Streams of boulders extend out on all sides into the basin, the boulders uniformly decreasing in size with distance from the knolls. Under the microscope the rock is seen to be typically hyalo-pilitic in texture and to be practically free from phenocrysts, except for an occasional lath of plagioclase which is larger than its fellows. Minute black grains, apparently of iron oxides, are scattered rather uniformly through the mass.

The section along the railroad east of Miñaca to the edge of the Chihuahua basin seems to be wholly in volcanic rocks, among which the basic varieties greatly predominate.

Conclusions.

The structure of the Western Sierra Madre of the State of Chihuahua, as shown in the sections seen upon this journey, is not complicated. A foundation of marine Cretaceous limestones has been raised to an altitude of at least 1800 m. above the level of the sea. This elevation was accompanied by extreme regional metamorphism, as is evidenced by the limestone schists of Guaynopita and Dolores, the pressure coming from the west. An ancient andesite was associated with the limestone, being poured out upon it before or during the elevation just referred to. Post-Cretaceous intrusive granite occurs in great masses in and beneath the limestone and andesite. More recently there have been innumerable flows of basalt, andesite, dacite (?), trachyte and rhyolite, and ejections of the corresponding tuffs, burying the older terranes. Here and there sandstones have been laid down, while in the numerous inclosed basins among the mountains the original relief of the surface has been largely obliterated by the accumulated wash forming the basin sandstones and basin conglomerates. Erosion has advanced more rapidly from the west than from the east, and the resulting enormous cañons account for the present relief of the mountain peaks and ranges.

109°
108°
107°
106°
105°
104°
31°
30°
29
28°
27
26
NEW MEXICO
EL PASO
JUAREZ
3717
TEXAS
PELONCILLA
HACHET MTS.
El Paso
Bolsons
3970
MADRE & PACIFIC
MEDANOS
Guzman
3900
SIERRA
L. S. Maria
Janos
Grandes
Rio
RIO GRANDE
CASAS GRANDES
4775
R. Casas
CANDELARIA
Sr. Quitman
Rio Grande
Sr. San Blas
L. Patos
AHUMADA
MEXICAN CENTRAL
CHIHUAHUA
L. Salada
Sr. Hueso
Sr. Lucero
L. Agua Nueva
Sr. Grande
PRESIDIO del NORTE
OJINAGA
COYAME
LAS VIGAS
GRAND CAÑON
2100
SANTA HELENA
3600
Sr. San Carlos
Bo Pecillos
Conchos
R. S. DOMINGO
KAN. CITY MEX. & ORIENT.
TERRAZAS
Sr. Prima Vera
L. Bavicora
6925
3865
GUAYNOPITA
SAN PEDRO
WESTERN SIERRA MADRE
R. Aros
DOLORES
8530
7874
MULATOS
3425
TUTUACA
MIÑACA
6900
CHIHUAHUA & PACIFIC
R. R.
4633
CHIHUAHUA
S. EULALIA
5600
R. R.
YEPACHIC
PINOS ALTOS
7900
OCAMPO
5900
Rio Mayo
GUADELUPE
BOCOYNA
BATO PILAS
R. Conchos
SANTA ROSALIA
4000
R. Conchos
L. de Jaco
Bolson de Mapimi
Sr. Diablo
Sr. Almagre
Sr. Mojada
COAHUILA
JIMENEZ
M. C. R. R.
PARRAL
5700
SANTA BARBARA
L. de Palmas
L. Tabualita
LLUVIA de ORO
Rio Fuerte
SINALOA
GUADELUPE Y CALVO
DURANGO
SONORA
Scale 1in = 42 mi.
Approximate altitudes in feet.
A PRELIMINARY GEOGRAPHIC AND GEOLOGIC MAP of the STATE of CHIHUAHUA, MEXICO.
BY
ROB'T. T. HILL,
NEW YORK, 1907.
TERTIARY AND LATER DESERT FORMATIONS
TERTIARY AND LATER IGNEOUS ROCKS (INTRUSIVES AND ERUPTIVES)
CRETACEOUS
JURASSIC

59.57.2(94)

Article XIX.—RECORDS AND DESCRIPTIONS OF AUSTRALIAN ORTHOPTERA.

By James A. G. Rehn.

Academy of Natural Sciences of Philadelphia.

The material on which the present paper is based forms part of the Hy. Edwards Collection, now the property of the Museum. For the opportunity to study this material the author is indebted to Mr. William Beutenmüller, Curator of Entomology.

Eight new species and one new genus are here described, and of the six previously known genera represented in this series by new species three were hitherto unfigured.

FORFICULIDÆ.

Labidura truncata *Kirby.* Victoria. One male.

BLATTIDÆ.

Ischnoptera annulata *Tepper.* Victoria. One male.

Calolampra gracilis (*Brunner*). Victoria. One specimen. Tasmania. One specimen.

Platyzosteria melanaria *Erichson.* Victoria. One immature female.

Oniscosoma castanea *Brunner.* Victoria. One male, two females.

Panesthia australis *Brunner.* Victoria. One female. Queensland. One male.

ACRIDIDÆ.

Acrida nasuta *Linnæus.* Two males, one female.

Cryptobothrus[1] gen. nov.

Belonging to the Acridine group Gomphoceri and closer related to *Chorthippus* (*Stenobothrus*) than to the other genera of this group. As its general character is quite distinct from this genus a generic diagnosis is here given.

Form moderately compressed. Head with the face distinctly retreating, arcuate; fastigium trigonal, margins and apex acute, junction of the fastigium and frontal

[1] **Κρυπτος** hidden, **βοθρος** a pit or depression.

costa rounded; lateral foveolæ visible dorsad, longitudinal, impressed only by punctations; frontal costa sulcate ventrad of the ocellus; antennæ depressed, the distal section broader than the proximal. Pronotum with the caudal margin subrect-angulate, lateral carinæ distinctly converging caudad and slightly so cephalad, median carina distinct; lateral lobes deeper than long. Tegmina reaching beyond apex of abdomen; no stridulating field developed; no continuous intercalary vein present, an irregular substitute occupying the area. Wings ample. Caudal femora robust. Caudal tibiæ with eleven spines on the lateral margins, spurs slightly but not greatly unequal.

Type.— *C. chrysophorus* n. sp.

Cryptobothrus chrysophorus[1] n. sp.

Type, ♂; Victoria, Australia. Edwards Coll., Amer. Mus. Nat. Hist.

Size small. Head with the occiput slightly elevated above the level of the pronotum, very gently arcuate, the interspace between the eyes equal to the fastigium in width, the latter being slightly less than twice the interantennal width of the frontal costa, margins slightly acute angulate, elevated, disk almost wholly depressed inside the margins, no median carina present, when viewed laterad the angle of the fastigium and frontal costa is moderately rounded; lateral foveolæ distinct for their entire length when viewed dorsad, the depressed area produced almost entirely by punctations and distinctly longitudinal, over twice as long as broad and with the

Fig. 1. *Cryptobothrus chrysophorus* gen. et sp. nov. Lateral view of type. (× 3).

dorso-cephalic angle broadly rounded; frontal costa from a very small dorsal width, regularly expanding to the region between the antennæ, subequal ventrad of this and becoming obsolete immediately dorsad of the clypeal suture, strongly punctate dorsad of the ocellus, sulcate ventrad; supplementary facial carinæ regularly but not strongly divergent; eyes ovoid, distinctly flattened cephalad, slightly prominent when viewed dorsad, in length distinctly exceeding the infra-ocular sulcus; antennæ slightly shorter than the head and pronotum together, apex blunt. Pronotum with the cephalic margin very slightly angulate, caudal margin rectangulate with very slight emarginations laterad; median carina distinct, lateral carinæ at the narrowest point (middle of prozona) separated by less than half the greatest area between them (on the metazona); prozona slightly shorter than the metazona; lateral lobes deeper than long, ventral margin obliquely emarginate cephalad, truncate caudad. Tegmina extending beyond the apex of the abdomen by the

[1] Χρυσοφορος, *wearing gold.*

length of the pronotum; costal margin with a small proximal lobe, distal half of the same margin arcuate, apex rounded. Wings with the greatest width contained about twice in the length; area between the caudal rami of the discoidal vein and the median vein rather broad and with seven arcuate transverse veins which are rather regularly placed, this area having somewhat the appearance of similar developments found in certain American Acridinæ (Truxalinæ). Interspace between the mesosternal lobes distinctly but not greatly transverse; mesosternal lobes subattingent. Cerci simple; subgenital plate conical, not distinctly produced. Caudal femora robust, the length about twice as great as that of the head and pronotum together, the greatest width contained about three times in the length, dorsal outline slightly concave distad, ventral outline regularly convex; caudal tibiæ slightly sinuate.

General color broccoli brown, marked and washed with bistre and buff. Face very pale buff, antennæ becoming bistre distad. Pronotum with the dorsal section of the lateral lobes on the prozona bistre, the same color lapping over narrowly on the dorsum of the metazona, lateral carinæ marked with pale buff; metazona on the lateral lobes washed with reddish. Tegmina with the anal field, and a narrow area adjoining the same, buff, the remainder of the tegmen closely maculate with bistre on a buff ground, the maculations small, but varying in size among themselves, subquadrate and not sharply defined except between the mediastin and humeral veins where six of the largest size are distinctly indicated. Wings with the apex and the better part of the anterior field washed with bistre, remainder lemon yellow, weak mesad, strong proximad. Caudal femora with a median maculation on the dorsal face and the genicular region bistre, internal face bistre with a pale pregenicular area, ventral sulcus except for a pale pregenicular space scarlet; caudal tibiæ scarlet, the genicular region bistre, the spines tipped with black; caudal tarsi washed with scarlet. Abdomen orange-red dorsad.

Fig. 2. *Cryptobothrus chrysophorus* gen. et sp. nov. Dorsal view of head and pronotum. (× 3.)

Measurements.

Length of body	14.5 mm.
Length of pronotum	3.5 "
Greatest width of disk of pronotum	2.5 "
Length of tegmen	13.8 "
Greatest width of tegmen	2.8 "
Length of caudal femur	10.3 "

The type is the only specimen of the species examined.

Chortoicetes yorketownensis *Brancsik.*

Victoria. One female. This species was described from Yorketown, South Australia.

Chortoicetes affinis n. sp.

Type, ♂; New South Wales, Australia. Edwards Coll., Amer. Mus. Nat. Hist. Allied to *C. yorketownensis* and *frater* Brancsik, but differing from the former in

the smaller size, the wholly sulcate frontal costa and some features of the coloration, while from the other species it differs in the larger size and in the cephalic margin of the wing not being infuscate.

Size rather small; form elongate, moderately compressed. Head with the occiput and vertex distinctly elevated above the level of the pronotum, arcuate; interspace between the eyes slightly more than once and a half the inter-antennal width of the frontal costa; fastigium very slightly wider than the interocular space, about as long as broad, the margins regularly converging cephalad and separated at the apex by a slight space, the lateral margins continued ventrad into the frontal costa; lateral foveolæ visible dorsad for their entire length, sublanceolate, the greatest width caudad and contained about twice in the length; angle of the fastigium and face rounded when viewed laterad, face gently but very decidedly retreating; frontal costa regularly expanding from its junction with the fastigium, where it is about half the width it is at the ocellus, margins carinate, failing by a narrow space to reach the clypeal suture, sulcate through its length, but not so strongly dorsad as ventrad of the ocellus; eyes ovate, hardly prominent when viewed dorsad, in length distinctly but not greatly longer than the infra-ocular sulcus; antennæ slightly depressed. Pronotum very slightly depressed mesad; cephalic margin of the disk very slightly angulate, caudal margin rounded obtuse-angulate, lateral carinæ constricted near the middle of the prozona, diverging considerably and equally in proportion cephalad and caudad, median carina distinct, low; metazona slightly more than once and a half the length of the prozona; lateral lobes slightly deeper than long, ventral margin obtuse-angulate. Tegmina elongate, narrow, exceeding the apex of the abdomen by more than the length of the head and pronotum; costal margin with a very low, slightly marked, proximal dilation, apex rounded with a slight tendency toward oblique truncation; intercalary vein strongly developed, branching from the median vein at about two-hirds the length of the intercalary area, and as a whole lying closer to the median than to the ulnar vein, anterior intercalary area with a number of very short cross veins, posterior intercalary area with irregular oblique veins in the proximal half, but the distal half is supplied with nine or ten regularly spaced oblique cross veins separated by rhomboid spaces. Wings large. Interspace between the mesosternal lobes subquadrate, the angles of the lobes rounded. Cerci simple. Caudal femora of medium build, slightly less than two-thirds as long as the tegmina; caudal tibiæ with ten spines on the lateral margins, spurs subequal.

Fig. 3. *Chortoicetes affinis* n. sp. Lateral view of type. ($\times 2\frac{1}{2}$).

General color wood brown marked with vandyke brown. Head with the face washed with cinnamon, dorsum of the head obscurely lined with vandyke brown, a narrow postocular streak of the same color also present; eyes raw umber. Pronotum with the dorsum touched with cinnamon on the prozona, blending into drab on the metazona, the dorsal section of the prozonal portion of the lateral lobes and the mesad margin of the lateral carinæ caudad of the constriction vandyke brown, the lateral carinæ ochraceous buff. Tegmina semi-hyaline with four patches of

vandyke brown extending caudad nearly to the posterior ulnar vein, the two median ones, placed near the middle of the tegmen, being very distinct and subquadrate, the proximal and distal ones irregular, the interspaces touched with buffy, apex and anal field with subquadrate blotches. Wings hyaline with the apex narrowly suffused with brown. Caudal femora with two faint bars on the dorsal face, lateral carinæ with a number of blackish-brown maculations, genicular region suffused, ventral sulcus flushed with pinkish-red; caudal tibiæ with the distal two-thirds pinkish, the genicular region vandyke brown, the proximal third very pale buff, spines and spurs tipped with buff; tarsi buffy.

Measurements.

Length of body	20.6 mm.
Length of pronotum	4. "
Greatest width of disk of pronotum	3. "
Length of tegmen	23. "
Length of caudal femur	12.8 "

The type is unique.

Chortoicetes pusillulus n. sp.

Type, ♂; Victoria, Australia. Edwards Coll. Amer. Mus. Nat. Hist.

Allied to *C. jungi* Brancsik[1] but differing in the much smaller size, the absence of maculations on the anal area of the tegmina and of any reddish coloration on the limbs.

Size very small; form moderately slender. Head with the occiput distinctly and considerably ascending to the vertex, the width of the latter (interocular) about two and a half times the width of the narrowest part of the frontal costa; fastigium considerably declivent, the lateral foveolæ causing the distinct margins to be concavely convergent, the separation from the frontal costa being made by a poorly defined transverse ridge, the lateral carinæ of the costa being continuous with those of the fastigium; lateral foveolæ elongate subtrigonal; frontal costa slightly expanding ventrad except for an area in the vicinity of the median ocellus where it is subequal, distinctly but not greatly sulcate throughout except ventrad; eyes ovate, somewhat flattened cephalad, slightly prominent when viewed dorsad, the length considerably more than that of the infra-ocular sulcus; antennæ about half again as long as the head and pronotum together, apex acuminate. Pronotum slightly longer than the dorsal length of the head, cephalic margin of the disk gently arcuate, caudal margin obtuse-angulate with the apex rounded, lateral carinæ weak, strongly constricted at the middle of the prozona, the carinæ almost obsolete on the section of closest proximity; lateral lobes distinctly deeper than long, the ventral margin broadly obtuse-angulate. Tegmina somewhat exceeding the tips of the caudal femora, apical section slightly narrower than the median and curved somewhat toward the sutural mar-

Fig. 4. *Chortoicetes pusillulus* n. sp. Lateral view of type. (× 3).

[1] Jahresb., Naturwiss. Ver. Trencsén, Comit., Trencsén, XIX–XX, pp. 70–71.

gin, apical margin rounded; intercalary vein nearer the median vein in the distal two-thirds, nearer to the ulnar vein in the proximal third. Wings ample. Interspace between the mesosternal lobes strongly transverse, the angles of the lobes obliquely rounded; interspace between the metasternal lobes very small, subquadrate. Caudal femora nearly two-thirds the length of the body, moderately robust, the greatest width contained nearly three times in the length, paginæ deeply sculptured; caudal tibiæ with ten spines on the lateral margins, spurs decidedly but not exceptionally unequal.

General color buff, marked and sprinkled with mummy brown. Head pale drab dorsad and bearing a pair of sub-equidistant lines of mummy-brown on the occiput and several short bars on each side caudad of the eyes; face and ventral portion of the head strongly yellowish buff; eyes tawny olive; antennæ indistinctly annulate with brownish, the apex darker than the base. Pronotum with the disk and the dorsal half of the lateral lobes washed with mummy brown, the median section of the prozona, the caudal section of the metazonal disk and the lateral carinæ buffy, the carinæ of the metazona being broadly and distinctly marked, a poorly defined pale oblique line is present on the dorsal section of the lateral lobes, line of darker color on the lateral lobes sigmoid and bordered with blackish on the prozona. Tegmina buffy proximad, hyaline distad, a series of about seven subquadrate blotches of mummy brown placed in a longitudinal series extending three-fourths the length of the middle of the tegmina. Wings hyaline. Caudal femora with several dorsal patches, one indistinct and proximal, one median and large, another pregenicular, a fourth involving the genæ and lobes, these blotches extending a considerable distance ventrad on the internal face, external face with shadowy indications of several oblique bars, marginal carinæ of the external face punctate with blackish-brown, particularly the ventral one; caudal tibiæ very weak olive-yellow, the spines blackish for at least half their length.

Measurements.

Length of body	12.5 mm.
Length of pronotum	2.5 "
Length of tegmen	11.5 "
Length of caudal femur	8.1 "

A topotypic male has also been examined. It is somewhat smaller than the type and of a more sharply contrasted coloration. The oblique bars on the lateral face of the caudal femora are well defined, and the carinæ without maculations, the dorsum of the head and pronotum has a median longitudinal subequal pale bar and the extreme apex of the wing also has sub-linear markings.

Aiolopus tamulus (*Fabricius*). New South Wales. One female.

Œdaleus marmoratus (*Thunberg*). Victoria. One female.

Œdaleus nigro-fasciatus australis *Saussure.* New South Wales. One female.

Œdaleus senegalensis *Krauss.* New South Wales. One male. This species has been recorded from Australia by Saussure.

Atractomorpha australis n. sp.

Type, ♀; New South Wales, Australia. Edwards Coll., Amer. Mus. Nat. Hist.

Closely allied to *A. australiana* Bolivar from Rockhampton, Queensland, but differing in the shorter head and fastigium, the shorter tegmina and decidedly shorter and narrower wings and longer caudal limbs.

Size medium; form as usual in the genus. Head on the dorsum nearly two-thirds the length of the pronotum; occiput hardly arcuate; fastigium slightly longer than broad, tapering, the apical margins curved but the apex not distinctly rounded and with a slight angulation; frontal costa narrow, compressed between the antennæ, slightly expanded immediately ventrad, subequal thence to the clypeal suture except for a slight expansion around the ocellus, shallowly sulcate except in the constricted dorsal section; face very greatly retreating, concave; eyes sub-ovoid, slightly flattened caudad, length slightly less than that of the fastigium; tubercles ventro-caudad of eye distinct and rather large; antennæ distinctly but not greatly shorter than the pronotum, thick, apex slightly tapering. Pronotum with the cephalic margin of the disk sub-truncate, caudal margin obtuse-angulate with a shallow median emargination, lateral angles of the disk carinate on the cephalic two-thirds of the prozona, distinct but not carinate on the remaining por-

Fig. 5. *Atractomorpha australis* n. sp. Dorsal view of type. (× 1½.)

tions, the greatest caudal width of the disk contained about two and one-third times in the length, median carina distinct, prozona occupying about three-fifths the length of the pronotum, disk of the metazona irregularly lineato-rugose; lateral lobes nearly twice as long as deep at the ventro-caudal angle, ventral margin oblique, following the line of tubercles ventro-caudad of the eye and provided with excrescences of the same character, caudal margin rotundate-emarginate. Tegmina about twice as long as the head and pronotum together, elongate lanceolate, costal margin with a moderate proximal lobation. Wings about two-thirds the length of the tegmina, narrow, the width contained three times in the length; apex acute. Prosternal projection transverse, truncate; interspace between the mesosternal lobes slightly transverse, the cephalic width slightly greater than the caudal; interspace between the metasternal lobes strongly transverse, very shallow. Caudal femora as long as the abdomen, slender, tapering in the distal two-thirds, pattern of the paginæ almost obsolete; caudal tibiæ about five-sixths the length of the femora, lateral margins with ten spines, internal margins with eleven.

General color chrome yellow, olive-yellow on the caudal section of the pronotal disk; tegmina olive-yellow; wings pale olive-yellow along the veins of the anterior field, posterior field suffused with geranium pink, the color becoming weaker distad and always stronger along and in the immediate vicinity of the dorsal veins.

Measurements.

Length of body	32.	mm.
Length of head (dorsal)	5.	"
Length of pronotum	8.	"
Length of tegmen	25.	"
Greatest width of tegmen	4.	"
Length of wing	17.3	"
Greatest width of wing	5.6	"
Length of caudal femur	16.3	"

The type is the only specimen of the species seen.

Azelota *Brunner.*

Azelota diversipes n. sp.

Type, ♂; Victoria, Australia. Edwards Coll., Amer. Mus. Nat. Hist.

As no described species have been assigned to this genus no comparisons can be made.

Size medium; form somewhat compressed, fairly robust; surface of the head and thorax, rugose, rugulose or punctate. Head with the occiput slightly elevated about the disk of the pronotum, moderately arcuate but slightly flattened, area between the eyes about twice the width of the frontal costa at the ocellus and provided with three longitudinal carinæ, the lateral ones being short, the median continued over the occiput; fastigium very slightly declivent, slightly longer than broad, lanceolate, the greatest width caudad, margins distinctly carinate, the disk moderately excavated; lateral foveolæ hardly appreciable; angle of the fastigium and frontal costa moderately rounded when viewed laterad; face distinctly but

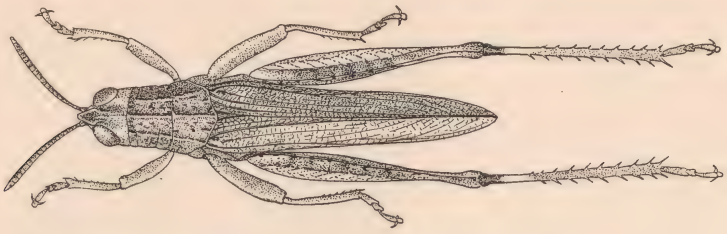


Fig 6. *Azelota diversipes* n. sp. Dorsal view of type. (× 2.)

not greatly retreating; frontal costa gradually but slightly expanding from the narrow dorsal section, sulcate ventrad of the ocellus and for a short distance dorsad of it; eyes ovate, slightly flattened cephalad, slightly prominent when viewed dorsad, in length nearly twice that of the infra-ocular sulcus; genæ rugose; antennæ slightly shorter than the head and pronotum together, distinctly depressed, slightly tapering distad, apex blunt. Pronotum with the disk nearly twice as long as the greatest caudal width of the same, cephalic margin of disk moderately arcuate, caudal margin obtuse-angulate in general form but in detail with a principal median arcuation and a pair of lateral ones, thus making a sinuation in the margin each side of the apex; lateral margins with low carinæ slightly expanding caudad, severed by at least two principal transverse sulci; median carina distinct, moderately high, slightly sinuate, divided, but not deeply, by the principal sulcus; metazona and pro-

zona subequal in length; disk with scattered subparallel linear rugosities; lateral lobes very slightly longer than deep, ventral margin obtuse-angulate, caudal margin oblique, slightly sinuate, prozona irregularly rugose, metazona closely rugulose. Tegmina reaching slightly beyond the apex of the abdomen; costal margin with a considerable proximal expansion, the distal third of the margin arcuate; apex rotundato-truncate; no intercalary vein present. Wings ample, width contained nearly twice in the length, apex blunt. Prosternal process transverse, strongly deflected caudad and distinctly broader at the apex than at the base, the apical margin with a slight median emargination; interspace between the mesosternal lobes subquadrate in proportions, subcuneiform in shape, the greatest width caudad; metasternal lobes subattingent. Abdomen considerably compressed; cerci about half again as long as the proximal width, sub-lanceolate, apex rather blunt and slightly decurved; subgenital plate subconical when viewed caudad, the apex narrow and very slightly divided. Cephalic and median limbs robust, femora, particularly the cephalic, inflated, cephalic femora moderately curved. Caudal femora about as long as the dorsal length of the abdomen, robust, the greatest width contained about three times in the length, dorsal carina sparsely serrate, ventral carina considerably arcuate, pagina distinctly and regularly but not deeply sculptured; caudal tibiæ about four-fifths the length of the femora, rather stout, supplied with eight strong spines on the lateral and nine on the internal margins, the apical spine on the lateral margins being absent, internal spurs subequal.

Fig. 7. *Azelota diversipes* n. sp. Lateral view of caudal limb. (×1½).

General color broccoli brown, inclining slightly toward greenish, ventral surface of the abdomen yellowish, eyes wax yellow; wings hyaline except for a slight apical suffusion, principal veins in other than the radiate field brown; caudal femora with the lateral and dorsal carinæ touched at regular intervals with blackish, genicular region suffused with dark brown, several obscure transverse bands are indicated on the internal face, the dark bars being blue black; caudal tibiæ with a dark genicular region, blackish on the inner face, a light pregenicular annulus is maize yellow on the internal face and hardly appreciable on the external, remainder of the tibia washed with heliotrope purple, particularly on the dorsal and internal faces, spines and spurs dull yellow with the apical half blackish; caudal tarsi carmine.

Measurements.

Length of body	22.5 mm.
Length of pronotum	5.2 "
Greatest caudal width of disk of pronotum	3.1 "
Length of tegmen	16.2 "
Greatest width of tegmen	3.5 "
Length of caudal femur	13. "

A paratypic male has also been examined and in all structural characters it fully agrees with the type although slightly smaller. In color it is distinctly darker, more olive than brown appearing in the general color, the disk of the pronotum, however, being rather ferrugineous and dark along the median carina, while the lighter color is continued on the anal field of the tegmina.

Exarna rugosa n. sp.

Type, probably female;[1] Victoria, Australia. Edwards Coll., Amer. Mus. Nat. Hist.

Allied to *E. despecta* Brancsik[2] from Yorketown, South Australia, but differing in the larger size, the sulcate ventral portion of the frontal costa, the less depressed and more cristate pronotum and the longer tegmina, as well as details of the coloration.

Size medium; form moderately robust; surface rugose as well as punctate. Head well placed within the pronotum, short, deep; occiput strongly and irregularly rugose, the interspace between the eyes slightly more than half the cephalocaudal width of the eye; fastigium with the greatest width slightly greater than the length, the disk, however, with the dimensions subequal and crudely hexagonal, the side at the junction with the frontal costa shorter than the others, open caudad, moderately excavate, a slight longitudinal median depression being noticed as well as two pairs of low, small tubercles placed about in the center; lateral foveolæ not

Fig. 8. *Exarna rugosa* n. sp. Lateral view of type. (× 2.)

marked, their usual situation being occupied by a number of low excrescences; frontal costa forming a slight angle with the face when viewed laterad, the costa itself being narrow dorsad, slightly expanding between the antennæ, from whence the width is subequal to the clypeal suture except for a slight constriction immediately ventrad of the ocellus, the section ventrad of the ocellus is distinctly sulcate, the dorsal section bears an irregular median carina due to the two parallel rows of irregular punctures, fastigium separated from the frontal costa by a transverse carina slightly weaker and lower than the lateral carinæ of the fastigium and costa; eyes subreniform, slightly prominent when viewed from the dorsum, in length distinctly longer than the infra-ocular sulcus; antennæ slightly shorter than the head and pronotum together, slightly depressed, blunt. Pronotum slightly inflated, punctate, sparsely but distinctly rugose, the length slightly more than the greatest caudal width of disk; cephalic margin gently arcuate, caudal margin obtuse-angulate, the angle blunt and the sides distinctly emarginate, laterad the disk rounds into the lateral lobes except on the metazona where a shoulder is noticeable; median carina cut by two transverse sulci, the metazona and prozona being subequal in length, the two sections into which the carina of the prozona is divided each being distinctly but not greatly elevated caudad, the metazonal portion of the carina being quite low; lateral lobes nearly equally as long as deep, the ventral margin

[1] The apex of the abdomen is missing.
[2] Jahresb. Naturw. Ver. Trenc. Comit., Trencsén, XIX, p. 77, pl. iii, fig. 19.

obtuse-angulate, the surface of the lobes with three well marked sulci; the prozonal disk with irregular rugosities, the metazona with few rugosities and these longitudinal, parallel and limited to the cephalic section of the metazona. Tegmina about three and two-thirds times the length of the pronotum, apical section somewhat narrowed and apex rounded oblique subtruncate; intercalary vein absent, the area being filled with irregularly disposed nervures. Wings ample, the greatest width contained about two and one-fourth times in the length. Prosternal process erect, quite broad, blunt; interspace between the mesosternal lobes subquadrate, slightly narrower than the lobes; interspace between the metasternal lobes small, cuneiform. Cephalic limbs small and weak; median limbs slightly longer and more robust than the cephalic. Caudal femora nearly three-fourths the length of the tegmina, the greatest width contained about three and one-half times in the length, of medium build, dorsal carina distinctly serrate, paginæ well sculptured with ten to eleven chevrons; caudal tibiæ slightly shorter than the femora, external margin with eight or nine spines, no apical one present, internal margin with ten spines, internal spurs moderately long, subequal.

General colors drab and isabella color with an olive-greenish tendency on parts of the head and pronotum, the two base colors mingled and scrumbled together, contrasting only on the tegmina; eyes clay color, antennæ clove brown. Tegmina with scattered small quadrate maculations of drab, thickest and not so sharply defined about in the middle of the tegmina, weak on the distal third, almost absent from the sutural portion of the anal field. Wings chrome yellow in the proximal half shading into drab distad, the coloration being almost entirely on the veins. Abdomen with the segments strongly marked with clove brown on their proximo-lateral sections. Caudal femora with their carinæ regularly marked with clove brown, the pattern of the paginæ finely and closely dotted with the same, genicular arches drab, internal face with traces of three transverse bands dorsad, ventral portion and ventral sulcus carmine; caudal tibiæ carmine, rather purplish and blotched with buffy on the dorsal face, spines and spurs buffy with the tips black, tarsi mottled drab and wood brown.

Measurements.

Length of body (approximately)	27. mm.
Length of pronotum	5.5 "
Length of tegmen	21. "
Length of caudal femur	14.75 "

The type is unique.

Macrotona gracilis n. sp.

Type, ♀; Victoria, Australia. Edwards Coll., Amer. Mus. Nat. Hist.

Closely allied to *M. lineola* Brancsik[1] from Yorketown, South Australia, but differing in the slenderer body and narrower pronotum, shorter antennæ (considerably less than equal to the head and pronotum in length) and in some details of the coloration of the pronotum and caudal tibiæ.

Size medium; form rather slender, not noticeably compressed; surface smooth or very finely punctate. Head as long as the pronotum, occiput slightly but dis-

[1] Jahresb., Naturw. Ver. Trenc. Comit. Trencsén, XVII, p. 256.

tinctly elevated above the disk of the pronotum, moderately arcuate and gently declivent to the apex of the fastigium, interspace between the eyes about two-thirds the width of one of the same; fastigium slightly produced, acute-angulate, apex blunt, broad and rounded ventrad into the face, margins low and thick, disk very slightly excavate; outline of the face when viewed laterad strongly retreating; frontal costa regularly expanded ventrad from its junction with the fastigium, where it is nearly three times the width of the proximal antennal joint, the section ventrad of the ocellus without sharply defined margins, the whole not sulcate and with two rows of sparse punctures dorsad of the ocellus; eyes acute ovoid, flattened cephalad, not prominent, in length about three times that of the infra-ocular sulcus; antennæ as long as the head and half of the pronotum, depressed, apex blunt. Pronotum with the disk subequal in width, slightly expanding on the metazona, the median width contained once and a half in the length, cephalic margin subtruncate, caudal margin very slightly obtuse-angulate; median carina distinct, moderately high, cut by the principal sulcus slightly caudad of the middle, the other sulci not severing the carina; lateral angles distinct but not carinate, slightly rounded on the metazona; lateral lobes longer than deep, the caudal margin quite oblique and distinctly emarginate, ventral margin obtuse-angulate. Tegmina more than twice the length of the head and pronotum and reaching to the apex of the abdomen, narrow, the greatest width being contained nearly six times in the length, subequal, the apex bluntly rounded; costal margin with a very slight proximal expansion; intercalary area occupied by an irregular, sinuate vein; mediastine and axillary veins strongly developed, the latter quite straight. Wings long and rather narrow, the costal margin gently sigmoid. Prosternal process broad, strongly transverse, the apical width greater than the proximal, the apical margin and the cephalic side of the apex roundly emarginate, the whole slightly depressed; interspace between the mesosternal lobes clepsydral, narrow, the length greatly exceeding the width; metasternal lobes contiguous caudad. Cephalic and median limbs slender. Caudal femora distinctly more than half the length of the body, well shaped, the proximal expansion contained slightly more than four times in the length, the pregenicular portion slender, the ventral outline less curved than the dorsal, carinæ smooth, paginæ with the pattern distinctly but not deeply sculptured, distinctly chevron-shaped; caudal tibiæ distinctly shorter than the femora, armed on the lateral margins with eleven or twelve and on the internal margins with twelve or thirteen spines, the lateral margins without apical spine; internal spurs subequal, strongly falcate.

Fig. 9. *Macrotona gracilis* n. sp. Lateral view of type. (× 2.)

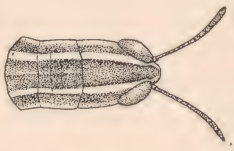


Fig. 10. *Macrotona gracilis* n. sp. Dorsal view of head and pronotum. (× 2.)

General colors buff-yellow and bistre. Head buff-yellow ventrad, dorsad with a pair of chrome yellow bars extending from the sides of the fastigium caudad, moderately diverging, very narrow where they pass along the dorsal margin of the eyes

and moderately broad caudad, the enclosed dark median section being margined laterad by velvety clove brown, the dark post-ocular bar moderately wide, broadening caudad and with a slight line of chrome yellow along its ventral border; eyes burnt umber; antennæ buffy proximad, bistre distad. Pronotum with the chrome yellow bars of the head continued along the lateral angles, subequal in width to the portions on the caudal sections of the head, slightly widened caudad, the dark median area bordered as on the head; lateral lobes with a broad bistre area dorsad, the cephalic margin for a considerable distance yellow as is the ventral section, thus limiting the cephalic marginal width of the brown to that of the postocular bar of the head with which it is continuous, ventral margin of the blotch slightly oblique, ventro-caudad in direction. Tegmina with the anal vein marked with a continuation of the chrome yellow bands, gradually becoming obsolete, remainder of the tegmina with the venation and some indistinct blotches and clouds on the membrane bistre. Wings with the apex narrowly clouded with drab. Pleura with the bistre and yellow division of the lateral lobes of the pronotum continued on them, a space in front of the articulation of the caudal limbs also bistre. Ventral surface and abdomen buff-yellow the latter with the faintest suggestion of orange-buff dorsad. Cephalic and median limbs buff-yellow, touched with clay color, the femora lined laterad more or less distinctly with bistre. Caudal femora buff-yellow with the dorsal half to two-thirds of the paginæ clove brown, a pale pregenicular annulus not interrupted, the genicular region punctate and clouded with clove brown and bistre, internal face with two clove brown maculations, one occupying the proximal half, elongate and only on the dorsal half, the other in the distal third and covering the whole internal face, dorsal face with slight suffused indications of the internal maculations, ventral sulcus not marked with any dark color; caudal tibiæ with the distal half flame scarlet, a broad pregenicular annulus pale buff-yellow, the internal genicular section and the section between the flame scarlet and buff-yellow bistre, spines with half their length blackish; caudal tarsi touched dorsad with flame scarlet.

Measurements.

Length of body	25.6 mm.
Length of pronotum	4.2 "
Length of tegmen	18. "
Length of caudal femur	14.1 "

The type is the only specimen of the species seen by the author.

TETTIGONIDÆ.

Acridopeza reticulata *Guérin.* Victoria. One female.

Ephippithyta biramosa n. sp.

Type, ♂; Queensland, Australia. Edwards Coll., Amer. Mus. Nat. Hist.

Closely allied to *E. trigintiduo-guttata* Serville, but differing in the biramose median vein of the tegmina, the foramina of the cephalic tibiæ being more elongate and the tegminal maculations distinctly smaller. Comparison has been made with Sydney specimens of *E. trigintiduo-guttata.*

Size rather large; form as usual in the genus. Head with the occiput considerably inflated, globose; fastigium of the vertex very narrow, sulcate, provided with a slight proximal inflation; facial fastigium rather short, not touching the fastigium of the vertex; eyes ovate, very prominent, infraocular region with a low carinæ; antennæ very considerably exceeding the body in length, filiform. Pronotum subsellate, the disk, however, flat; cephalic margin very slightly emarginate, caudal margin flattened arcuate, the disk much constricted on the prozona and strongly expanded on the metazona where it is slightly concave; lateral lobes not separated from the disk by any sharply defined shoulder, the nearest approach to such being on the metazona, the depth of the lobes distinctly greater than the dorsal length, ventral margin strongly arcuate. Tegmina elongate, lanceolate, the greatest width at a third the distance from the base, the same dimension being contained nearly five times in the length; costal margin gently arcuate in the proximal half, straight thence nearly to the apex, sutural margin straight, apex narrowly rounded; costal field at no point more than two-thirds the width of the remainder of the tegmen, irregularly areolate; median vein diverging slightly proximad of the middle and bearing two rather closely placed rami which reach the sutural margin. Wings very large, apex acute, costal margin slightly arcuate, ulnar vein with four rami in the distal two-thirds. Cerci falciform, slightly depressed at the apex and crossing one over the other. Prosternum without spines, mesosternum with acute

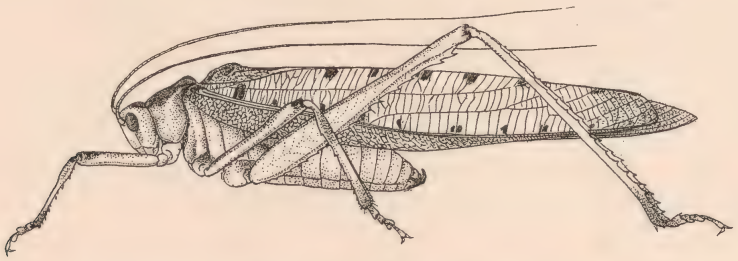


Fig. 11. *Ephippithyta biramosa* n. sp. Lateral size of type. Natural size.

trigonal lobes, metasternal lobes sub-rectangulate caudad. Cephalic femora about equal to the head and pronotum together in length, slightly compressed, cephalic margin armed with six spines, caudal margin unarmed; cephalic tibiæ very slightly longer than the femora, foramina elliptical on both faces, ventral margins well spined, the dorso-caudal margin with four spines, the dorso-cephalic unarmed. Median femora slightly longer than the greatest width of the tegmina, ventral margins somewhat lamellate, particularly distad, the cephalic armed with eight spines, genicular lobes both armed with a long spine; median tibiæ slightly longer than the femora, compressed, considerably expanded in the proximal third, cephalo-dorsalo-cephalic margin with three and the dorso-caudad with six spines. Caudal femora somewhat shorter than the body, slender, the ventral borders sublamellate and armed with spines, those distad being large, those proximad small, eighteen to twenty in number on the lateral and sixteen on the internal margins; caudal tibiæ distinctly but not greatly longer than the femora, quadrate in section, all the margins spined, the dorsal ones with larger and more numerous spines than the ventral.

General colors pale olive-green and saffron yellow. Head with the interocular region and the top of the occiput bistre, face and sides of head cream buff; eyes clay color; antennæ greenish proximad becoming cinnamon-rufous distad and mesad,

the whole with the articulations usually indicated by pale annuli. Pronotum with the disk washed with brown, the narrow clepsydral cephalic section bistre with a narrow wood brown median line, the metazonal section russet with clove brown lateral portions; lateral lobes saffron yellow. Tegmina pale olive-green, the distal half of the costal field and the region between the discoidal and median veins brick red; sutural margin narrowly lined with the same color which is also shared by the tympanal venation; the area immediately mesad of the median vein decorated with six to nine small blotches of clove brown of variable size, several being as large as a millimeter and a half square while others are little more than points of color, sutural margin with six blotches of the same color which are a rule slightly larger and more quadrate. Wings hyaline, the veins pale greenish, coriaceous apex of the anterior field greenish, the distal section of the costal margin brick red. Abdomen greenish ventrad, vinaceous-rufous dorsad. Cephalic and median limbs dull saffron yellow, the genicular region of the femora and the caudal section of the genicular region of the tibiæ clove brown, foramina and articulation of the tarsi of the same color. Caudal femora greenish-yellow, spines tipped and genicular region edged with blackish brown; tibiæ the same color as the femora, suffused distad.

Measurements.

Length of body	32.5 mm.
Length of pronotum	6.1 "
Greatest caudal width of disk of pronotum	5.1 "
Length of tegmen	51. "
Greatest caudal width of tegmen	11.2 "
Greatest width of the costal field	4.8 "
Length of caudal femur	30. "

The type is the only specimen of the species examined.

Cædicia olivacea *Brunner.* New South Wales. One male. New Zealand. One female.

These specimens have the tegmina narrower in width than twice the length of the pronotum as described by Brunner.

Elephantodeta farinosa *Brunner.* New South Wales. One female.

Conocephalus longiceps *Redtenbacher.* Queensland. One male.

This specimen is somewhat larger than the original measurements given by Redtenbacher, but the differences are not greater than those sometimes found in other species of the genus.

Gryllacris major *Brunner.* Victoria. One female.

This specimen agrees fully with the description of the species except that the ovipositor is several millimeters shorter than the type measurement.

56.53,841H(117:78.6)

Article XX.— NOTICE OF AN AMERICAN SPECIES OF THE GENUS HOPLOPARIA McCOY, FROM THE CRETACEOUS OF MONTANA.

By R. P. Whitfield.

Plate XXXVI.

So far as I can learn, there has been no species of Hoploparia recognized in the American Cretaceous previous to this time. Prof. Bell in his Monograph of the Malacostracea, of the Green Sands of England, recognizes no less than six species, which he says are remarkably distinct specifically from each other; and this one from the Fort Pierre (or rather Fox Hills) strata of the Montana Cretaceous, is no less distinct from any of the others; it most nearly resembles *H. saxbyi* McCoy, but has many important differences.

The specimens of this American species were obtained during the summer of 1906, by Mr. Barnum Brown of the Museum, from concretions in limestone or shale, associated with many species of Fox Hills fossils, at a point 125 miles northwest of Miles City, Montana, about 150 feet below the basal sandstone of the Laramie beds. The caudal plate here figured was obtained by Mr. Brown in 1905, on Musselshell River, at Flat Willow Creek, 25 miles north of Musselshell crossing, Mont., also in a small concretion, and of course all are from Cretaceous rock, referable to the Fort Pierre and Fox Hills groups.

Hoploparia browni sp. nov.

Plate XXXVI, Figs. 1–5.

Represented by two abdomens, one of which has the carapace entirely attached, except the rostral beak; and it also retains part of the middle member of the caudal plate. There is also a caudal plate nearly entire, and a second abdomen of smaller size, retaining much of the caudal plate.

Carapace subcylindrical, twice as long as wide and fully as high as wide; broadly suboval in sections, length (on the larger specimen) about two inches (53 mm.); cervical suture very deep, extending but little more than half the depth of the carapace, situated about midway the length of the carapace on the dorsum, but curving strongly forward to the lower end, preceded by a second less strongly marked furrow at about the distance of one cm., which is more direct in its trend downward toward the basal margin of the carapace, where it unites with the cervical[1]

[1] It is possible I have reversed the terms cervical and nuchal in relation to these sutures.

suture by a short horizontal depression. Carapace ornamented by short, sharp tubercles, or pustules, node-like, in rows or curves. Five longitudinal rows exist on the back of the front half of the carapace, or in front of the cervical suture, and three longitudinal rows, behind the suture on the dorsum, the outer of which curve downwards bordering the suture, becoming smaller and less compact on the sides of the carapace. Behind the cervical suture the pustules are smaller and scattered over the sides of the entire carapace; the pustules bordering the posterior margin of the cervical furrow on the back of the carapace are somewhat detached from the two curved lines of the sides and are stronger and closer than the others, and with the central line forms a rather distinct letter T.

Abdominal segments armed by large lateral flaps of a paraboloid outline, each bearing a terminal node at the outer free end. A strong angular thickened knee or ridge exists at the bending on the sides, where the flaps become free from the segment, and along the crest of the segment there is a line of small postules, which are not always distinct.

Anterior caudal plate rather large, wider than long, hexagonal in outline; the lateral margins being doubly truncate for the insertion of the intercalated plate for the attachment of the two lateral flaps of the caudal appendage on each side, which are longitudinally elongate-ovate and of rather large size proportionally, making the caudal appendage appear large. Their large central plate is ornamented on the disc with spinose ridges and minutely pustulose. Central terminal plate of caudal appendage longer than wide, elongate paraboloid in outline, rounded posteriorly, with three obscure spines on each margin; center of plate bearing four ridges, the outer two united above in a transverse boss; each of the ridges on the crest is more or less marked by small pustules or granules. The lateral parts of the caudal plate are each composed of the usual three elements on each side, the outer plate bearing two longitudinal ridges and the inner, only one.

The left anterior claw of the larger specimen is partly preserved. The hand, or main joint, and the two joints next to it nearer the body, are preserved but forward of the hand or main joint, the imprint and only fragments remain. The fingers are excessively prolonged and slender, in fact the entire claw is very slender; the movable finger is laterally compressed and transversely ridged, or ringed, and the imprint on the stone is preserved for over three inches in length, while the fixed one has been much shorter, and the nippers quite small and insignificant, the whole member apparently granulose. In the other limbs only the first joint attached to the carapace is preserved; but parts of them are seen in the matrix; all are slender and rather short.

Of the six species recorded from the Cretaceous formation of England, by Prof. Bell, four are from the Gault and the upper and lower Greensand, but it appears that the genus is not strictly confined to the Cretaceous beds, as a form essentially the same occurs in the London Clay. In America as yet no other species than the one here described has been noticed.

Prof. Bell considers the genus as of strictly Marine origin, and as being closely allied to *Homarus*. In one feature this species differs from the common American form of *Homarus*, namely in the strong knee-like ridges which mark the angle of the abdominal segments on each side, where the lateral flaps become free from the body, which are here very marked and

angularly thickened, while in most species of *Homarus,* as well in most fluvial species of *Astacus,* this feature is very subdued. On one species of *Astacus* (*Cambarus immunis* Hagen), which occurs at Lawn Ridge and Belleville in Illinois, at Huntville, Ala., and at Beaufort, N. Car., this feature is as strongly marked as on these Cretaceous specimens.

This American species differs from *H. saxbyi* in some important features; most distinctly in the depth of the nuchal furrow, in the shorter carapace, and in being more pustulose. Also in the shorter abdominal segments, and in the form and size of the anterior plate of the caudal appendage.

The large claw of this species can hardly serve for comparison with that figured by Prof. Bell (plate viii, fig. 2, Palæontography. Soc. Pub., Malacstracous Crustacea of Great Britain), as there is some reason to think that the large claw on this specimen has been lost during life and partially reproduced; as it is evidently much too small and insignificant to properly mate with the opposite finger on the same arm, except on that supposition.

EXPLANATION OF PLATE XXXVI.

Hoploparia browni sp. nov.

Fig. 1 and 2. Dorsal and profile views, natural size, of the larger and most perfect specimen.

Fig. 3. View of caudal plate, natural size, from Musselshell River, Flat Willow Creek, Mont.

Fig. 4. View of the claw of the specimen, figs. 1 and 2, as it lies imbedded in the stone. This was originally a part of the same slab that contained the carapace figured but was broken from it in collecting.

Fig. 5. View of the opposite side of the hand, natural size.

The caudal plate, restored in part in Fig. 1, is shown on the specimen only as a flattened surface without distinct form, and is reproduced from the corresponding plate represented in Fig. 3.

Hoploparia browni sp. nov.

59.57,92C(7)

Article XXI.—NOTES ON A FEW NORTH AMERICAN CYNIPIDÆ, WITH DESCRIPTIONS OF NEW SPECIES.

By William Beutenmüller.

Plate XXXVII, Figs. 1–10.

Andricus davisi sp. nov.

Male.— Head yellowish brown with a large round spot on the vertex; front rugose-striate; vertex and posterior portion minutely punctate. Antennæ 14-jointed, yellowish brown. Thorax finely and evenly rugose at the sides, with the portion between the parapsidal grooves somewhat transversely rugose posteriorly; black, subopaque, anterior portion of the side to the scutellum yellowish brown, underside black. Parapsidal grooves distinct, narrow, rather deep, and widely separated at the scutellum; anterior pair of lines very fine, smooth and short; median groove from scutellum wanting. Pleuræ finely rugoso-punctate. Scutellum black, very rugose. Abdomen shining black, with the underside dull yellowish brown or piceous. Legs yellowish brown with minute hairs. Wings hyaline with yellowish veins.

Length 2–2.50 mm.

Female.— Head yellowish brown with a large black patch on the face; vertex and posterior portion black; antennæ yellowish brown. The yellowish brown color extends to the side and narrowly around the eyes. Thorax black, with a rufous patch on the pleuræ and sometimes at the sides anteriorly. Scutellum black. Abdomen shining black, somewhat rufo-piceous along the underside. Legs dull yellowish brown, somewhat infuscated, especially the hind femora and tibiæ which are very piceous. Otherwise like the male.

Length 2.50–3.25 mm.

Gall (Plate XXXVII, Figs. 1–6).— Polythalamous. Brown, sometimes speckled with pale brown. Smooth or somewhat roughened. Globular, irregularly rounded or somewhat elongate. They are single or in clusters, or a number of them coalesce forming a large knot-like mass. They are very hard, solid and woody, and contain many larval cells. The individual gall measures from 4 to 15 mm. in diameter, and the knot-like mass measures about 40 mm. in width.

Habitat.— Lakehurst, New Jersey. September.

Types. Colls. Am. Mus. Hat. Hist. and W. T. Davis.

The gall occurs singly or in clusters of from two to about twenty individuals around the twigs and branches of scrub oak (*Quercus nana*). They sometimes coalesce and form a large knot-like mass, not unlike *Andricus cornigerus*, but without the horn-like projections which characterize the latter. The galls reach maturity late in September and the flies emerge the following spring. The flies are very distinct and may be known by

the very rough, transversely rugose thorax and the absence of the median groove at the scutellum.

The flies were described from numerous specimens bred by Mr. William T. Davis and myself.

I take pleasure in naming the species after Mr. Davis, who first called my attention to this distinct species of gall and gall-fly.

Andricus wheeleri sp. nov.

Female.— Head rufous, coarsely rugoso-punctate; eyes black or partly rufous; antennæ very long, 14-jointed, rufous. Thorax rufous, very coarsely rugose. The pair of lines on the middle, from the collar, are moderately long, smooth and divergent at the ends. Parapsidal grooves rather deep, distinct but not prominent, parallel but converging as they approach the scutellum where they are widely separated. Median groove from the scutellum wanting. Outside the parapsidal grooves is an abbreviated smooth line extending forward to about the middle. Scutellum very rugose. Pleuræ finely rugose, with a polished area beneath the wing. Abdomen rufous, shining. Legs rufous, with the hind tibiæ infuscated. Wings hyaline; veins brown.

Length 2.50–3.50 mm.

Gall (Plate XXXVII, Figs. 7–9).— Polythalamous. Brown with a grayish tint, hard and woody. Irregularly rounded or elongate, somewhat potato-shaped. Measures from about 14 to 20 mm. in width and from 15 to 30 mm. in length.

Habitat.— Coconino Forest, rim of the Grand Cañon, Arizona; altitude 7,000 feet. (William M. Wheeler).

Types. Coll. Am. Mus. Nat. Hist.

The galls of this species occur around the smaller twigs of an unknown species of scrub oak. They somewhat resemble *Andricus medullæ* and *batatoides* Ashmead, but the fly is different. The flies may be distinguished by the divergent anterior lines, absence of the median groove from the scutellum, and rufous color. It is allied to *Andricus medullæ* Ashmead.

Andricus coronus sp. nov.

Female.— Head not broader than the thorax, yellowish brown, finely and evenly rugose. Eyes and ocelli black. Antennæ 14-jointed, yellowish brown. Thorax prominently rounded on top, yellowish brown, evenly and finely rugose. The pair of anterior grooves from the collar fine and narrow, extending to about the middle of the thorax. Median groove from the scutellum extending well forward to nearly the collar. Parapsidal grooves fine and narrow to the middle, thence gradually becoming broader as they approach the scutellum; subparallel and rather widely separated from the median groove at the scutellum. Scutellum rugose, with two distinct, large, shining foveæ at the base separated by a narrow ridge. Pleuræ rugose without shining areæ. Abdomen almost globose, yellowish brown. Legs yellowish brown, with the claws black. Wings hyaline with honey-yellow veins.

Length 2.50–3 mm.

Gall (Plate XXXVII, Fig. 10).— Monothalamous. Pale green; soft when fresh, hard and pithy when dry. Rounded, somewhat crown-shaped, with prominent ridges at the side from the base, meeting at the apex; base pointed. Thick walled, with a large round larval cell in the center.

Length 8–12 mm.; width 6–12 mm.

Habitat.— Bronx Park, New York City, May 18, 1905; Atlanta, Georgia (R. I. Smith); Mississippi.

Types. Coll. Am. Mus. Nat. Hist.

The gall may be found in New York, in clusters on the small terminal twigs of pin oak (*Quercus palustris*) during the middle of May, and in Georgia on water oak (*Quercus aquatica*) during March. When mature, they drop to the ground or will readily break off when touched. The imago becomes fully developed in the gall by October, but does not emerge until the following spring. The fly may be known by its yellowish brown color, black eyes and ocelli, and by the lines on the thorax, especially the parapsidal grooves which widen as they approach the scutellum. The gall-fly was described from five females.

Andricus coxii *Bassett.*

Cynips coxii Bassett, Can. Ent., Vol. XIII, 1881, p. 112.

Andricus coxii Ashmead, Trans. Am. Ent. Soc. Vol. XII, 1885, p. 295; *ibid.*, Vol. XIV, 1887, p. 132; Dalla Torre and Kieffer, Gen. Insect. Hymenop. Cynip., 1902, p. 62.

Andricus coxi Bassett, Trans. Am. Ent. Soc., Vol. XXVI, 1900, p. 320.

Andricus bassettianus Dalla Torre and Kieffer, Gen. Insect. Hymenop. Cynip., 1902, p. 61.

This species was described as *Cynips coxii* by the late Homer F. Bassett and was subsequently placed in the genus *Andricus* by Dr. William H. Ashmead. Bassett some years later redescribed, as new, his *Cynips coxii* under the name *Andricus coxi*, evidently having forgotten that he had already published the description of his species. Dalla Torre and Kieffer, not knowing that both of Bassett's names applied to one and the same species, changed the name of the one described last by Bassett to *Andricus bassettianus*. The synonymy of the species will therefore have to stand as given in the above references.

Holcaspis perniciosus *Bassett.*

Holcaspis perniciosus Bassett, Trans. Am. Ent. Soc., Vol. XVII, 1890, p. 68.

Holcaspis monticola Gillette, Ent. News, Vol. IV, 1893, p. 30.

Two female types and several galls of *Holcaspis monticola* Gillette were kindly given to me by Dr. C. P. Gillette, and they are identical with *Holcaspis perniciosus* Bassett, there being no differences whatever.

Acraspis macrocarpæ *Bassett.*

Acraspis macrocarpæ BASSETT, Trans. Am. Ent. Soc., Vol. XVII, 1890, p. 84.
Acraspis undulata GILLETTE, Ent. News, Vol. IV, 1893, p. 28.

Two type specimens of the gall-flies and several galls of *Acraspis undulata* were kindly given to me by Dr. C. P. Gillette. Although Dr. Gillette points out some differences between the flies of *A. undulata* and *A. macrocarpæ*, I fail to see any differences whatever between the two species. The galls of *A. undulata* are also identical with those of *A. macrocarpæ*. The galls of *A. undulata* occur on the undersides of the leaves of *Quercus undulata*, and those of *A. macrocarpæ* on *Quercus macrocarpa*.

Dryophanta eburneus *Bassett.*

Dryophanta eburneus BASSETT, Trans. Am. Ent. Soc., Vol. XVII, 1890, p. 70.
Dryophanta glabra GILLETTE, Can. Ent., Vol. XXVI, 1894, p. 237.

Two gall-flies and several galls of *Dryophanta glabra* Gillette were given to me by Dr. C. P. Gillette and they are identical with *Dryophanta eburneus* Bassett.

Callirhytes tuberosa *Bassett.*

Andricus (*Callirhytis*) *tuberosa* BASSETT, Trans. Am. Ent. Soc., Vol. XXVI, 1900, p. 311.

A number of galls of this species were sent to me by Miss Annette F. Braun from Cincinnati, Ohio, collected on the shingle oak (*Quercus imbricaria*). Bassett described it from Waterbury, Connecticut, where it was found on the scrub oak (*Quercus nana*).

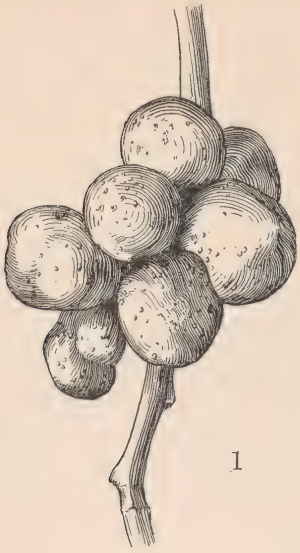
Neuroterus laurifoliæ *Ashmead.*

Neuroterus laurifoliæ ASHMEAD, Trans. Am. Ent. Soc., Vol. XIV, 1887, pp. 128, 140.

Specimens of the galls of this species were collected by Dr. Mel. T. Cook in Illinois on the leaves of the shingle oak (*Quercus imbricaria*) and by Miss Annette F. Braun at Cincinnati, Ohio, on the same kind of tree. Heretofore it was known from Florida, on the laurel oak (*Quercus laurifolia*).

EXPLANATION OF PLATE XXXVII.

Figs. 1–6.— *Andricus davisi* sp. nov.
Figs. 7–9.— *Andricus wheeleri* sp. nov.
Fig. 10.— *Andricus coronus* sp. nov.



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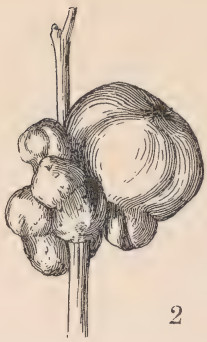

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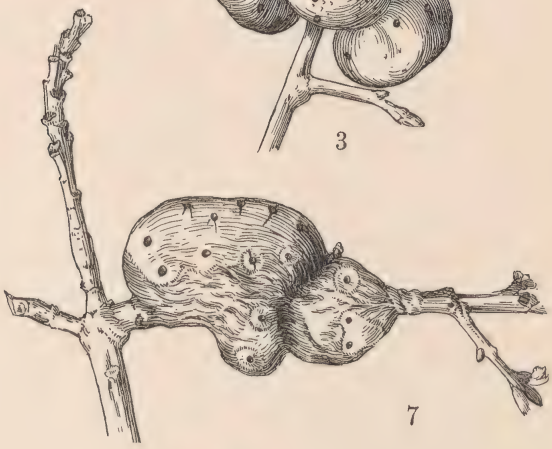

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Galls of New Cynipidæ.

59.88,1B:11.5

Article XXII.— THE BÆOLOPHUS BICOLOR-ATRICRISTATUS GROUP.

By J. A. Allen.

Instances of hybridization among birds, in a state of nature, are of well known occurrence, not only between closely allied or congeneric species, but between species remotely related, as between birds of different genera, notably among grouse and ducks. There are also many recorded instances of such mesalliance between different genera of song birds, as finches, warblers, swallows, etc. Such cases, however, are in the main sporadic, and are not commonly looked upon as of any great biologic importance. Under artificial conditions, as with birds confined in aviaries, or through man's interference, crosses between not only allied species, but even between species of widely different genera, may be obtained.

Hybridization in a state of nature, and habitually over large areas where the breeding ranges of the hybridizing species adjoin or overlap, has been satisfactorily demonstrated in comparatively few instances — perhaps in only two or three among North American birds. One is the well-known instance of the two North American species of *Colaptes*, which interbreed along the whole line of junction of their breeding areas, from Texas to the Saskatchewan.[1] The second is the almost equally famous case of two species of *Helminthophila*, *H. pinus* and *H. chrysoptera*, which freely interbreed in northern New Jersey, southeastern New York, and southern Connecticut, and probably also westward where their breeding ranges overlap. The third is the tentative instance of the Purple Grackle and Bronzed Grackle,— *Quiscalus quiscula* and *Q. æneus*,— investigated by Mr. Chapman in 1892,[2] and recently reëxamined by Mr. Ridgway.[3] The suggestion was made by Mr. Chapman that *Q. æneus* and *Q. aglaius* are distinct species, and that *quiscula* is the mixed product of the two through interbreeding. Mr. Ridgway favors the same hypothesis, agreeing fully with the view set forth by Mr. Chapman.

When intergradation between previously supposed "good species" began to force itself upon the attention of ornithologists, through the accumulation

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[1] *Cf.* Allen, The North American Species of the Genus *Colaptes*, considered with special Reference to the Relationships of *C. auratus* and *C. cafer*. Bull. Am. Mus. Nat. Hist., Vol. IV, 1892, pp. 21–44, with map.

[2] A Preliminary Study of the Grackles of the subgenus *Quiscalus*. Bull. Am. Mus. Nat. Hist., IV, pp. 1–20, with map.

[3] Birds of North and Middle America, Part II, 1902, pp. 214, 215.

of material from many new localities, twenty to thirty years ago and hence before geographical variation had become well known, a favorite method of disposing of intergrades was to consider them as merely "hybrids." As Chapman has said: "To call an intermediate a 'hybrid' is an easy way of answering what may be a difficult question. But unless the hybridization has been proven, it is a reply which gives no information whatever, and proves a stumbling-block to more thorough investigation." "It seems to me, however," he continues, "that given sufficient data on which to base any theory of the relationships of two intergrading forms,....we should not be in doubt as to whether they are connected through the action of purely environmental causes or by the more direct action of hybridization. The nature of their intermediate characters, the fact that these characters do not correlate with environmental influences, the presence of both species in the area occupied by their intergrades, all should furnish evidence which will enable us to distinguish between hybrids and geographical intermediates." [1]

Indeed, the fashion, so prevalent twenty years ago, of considering 'intergrades' as 'hybrids' between different 'species' rather than as connecting links between geographic phases of one and the same species, has practically become a feature of the past history of ornithology. Yet, as noted above, there are cases of intergradation that do not conform to any known conditions or methods of geographic intergradation, but do conform to known conditions and results of hybridization.

An assumed fourth case of intergradation through hybridization is furnished by the two forms of Crested Titmouse inhabiting central and southern Texas. One is the common Tufted Titmouse, *Bœolophus bicolor*, of the eastern United States, which ranges from the Atlantic coast to the Great Plains; the other is the Black-crested Titmouse, *Bœolophus atricristatus*, of eastern Mexico, which ranges from the highlands of Vera Cruz northward to central Texas. The breeding ranges of the two forms adjoin, or overlap, over a considerable area in southern and central Texas, where occur intermediates of rather peculiar and inconstant characters. These intermediates were first made known in 1887 by the late George B. Sennett, from specimens collected along the Aransas River in Bee County. On six specimens collected by Mr. J. M. Priour, April 4, 7, and 9, 1886, he based (Auk, IV, 1887, pp. 28, 29) his two subspecies, *Parus atricristatus castaneifrons* and *Parus bicolor texensis*, referring four of the specimens to the former and two to the latter, after comparison with a large series of true *atricristatus* on the one hand and true *bicolor* on the other. These birds all have

[1] Bull. Am. Mus. Nat. Hist., IV, 1902, p. 18.

the frontlet or forehead more or less chestnut instead of black as in *bicolor*, or white as in *atricristatus*. In '*castaneifrons*' the crest is blackish, but not as deep black as in *atricristatus*; in the male type of *texensis* the crest is distinctly darker than in *bicolor*, strongly tending to blackish; in the female type of *texensis* the darkening of the crown is scarcely perceptible. In two (the males) of the four specimens referred to *castaneifrons* the forehead is dull rufous-chestnut; in the other two (the females) it is white suffused with pale buff or cream-color; in the two *texensis* specimens the forehead is dull chestnut in both. In general size, in the size of the bill, and in general coloration, there is nothing to distinguish either subspecies from *bicolor* on the one hand or *atricristatus* on the other, the differences being confined to the forehead and crest.

Mr. Ridgway, in his 'Birds of North and Middle America' (part III, 1904, p. 386), treats both these forms as "hybrids," saying: "Any pronounced rusty tinge to the color of the forehead indicates, in the writer's opinion, admixture of *B. bicolor* blood. This reaches its extreme development in individuals corresponding to *Parus atricristatus castaneifrons* Sennett and *P. bicolor texensis* Sennett, the former comprising those with a black crown and crest and deep rusty or chestnut forehead, the latter those with a gray crown and crest and rusty or chestnut forehead. That these are all merely hybrids between *B. atricristatus sennetti* and *B. bicolor* is almost certain from the fact that they occur together in the same localities along with the two hypothetical parent species; furthermore, the National Museum collection contains two pairs shot at San Antonio, by Mr. H. P. Attwater, the males of which are typical *B. a. sennetti* and the females *B. b. texensis*."

Whatever may be the origin of these intergrades between *B. bicolor* and *B. atricristatus*, it is evident that Mr. Sennett's subspecies *castaneifrons* and *texensis* are but individual phases or degrees or stages of one and the same thing.

In order to understand the interrelationships of *B. bicolor* and *B. atricristatus* the two forms may be first considered from the standpoint of the geographic variation exhibited by each form.

Geographic Variation.

General Coloration.— In general coloration *B. bicolor* and *B. atricristatus* are essentially similar, both being gray above, varying in the breeding season from slaty gray in *bicolor* to olive gray in *atricristatus*; both are brownish gray in immature plumage, but *bicolor* is the more strongly so.

The gray tends more to slaty gray in *bicolor* and to greenish gray in *atricristatus*. But *bicolor* has generally a brownish olivaceous shade on the back in fresh adult plumage, instead of the greenish olivaceous shade present in the fresh adult plumage of *atricristatus*. This soon fades out in both, so that breeding specimens of the two forms are often indistinguishable in the color of the back. Both forms are also similar in color below, being dull white with the sides and flanks cinnamon-rufous, which tint varies greatly in intensity in different individuals of the same form.

The two marked features of differentiation are (1) the color of the forehead, and (2) the color of the crown and crest feathers.

Forehead.— In *B. bicolor* the color of the forehead varies from deep pure black to dull black bordered or suffused with rusty brown; in *B. atricristatus* it varies from clear white to creamy or buffy white.

Crown and Crest.— In *B. bicolor* the crown and crest are gray, of a little deeper and darker tint than the back; in *B. atricristatus* the crown and crest are black, in abrupt contrast with the back. The difference in these two features is radical — not of degree but of contrast. Also the crest is generally fuller and longer in *atricristatus* than in *bicolor*.

Individual Variation in Color of the Forehead.— In *B. bicolor* the color of the forehead is subject to a wide range of individual variation throughout the range of the species, birds with the forehead pure deep black occurring everywhere with birds in which the forehead is 'sooty' black or rusty brownish black. The rusty tint may be limited to the edges of the black area and barely perceptible, or it may form a conspicuous outer border, or the whole forehead may be distinctly or even strongly rusty beneath the surface of the feathers. In such cases the lores are frequently buffy white.

In the Atlantic States and westward to the Mississippi Valley the variation in the color of the forehead seems to be partly individual and partly sexual, and not to any appreciable degree geographical, specimens with the black frontlet suffused with rusty being not more frequent in the Carolinas and Florida than in New Jersey or Ohio. In eastern Kansas and Louisiana the few specimens at hand all show brown in the frontlet, while in Texas (Brasoria, Matagorda, Bexar, Lee, Victoria, and Uvalde Counties) specimens without more or less brown in the black of the forehead are exceptional, and the amount of brown suffusing the black is generally much greater than in even the most extreme examples from the Atlantic States.

In *B. atricristatus*, from the Valley of the Lower Rio Grande southward, the forehead is generally clear white, varying, however, through creamy white to cream-buff. The type locality of the species is the Lower Rio Grande Valley, somewhere between Brownsville and Rio Grande City, Texas. In a series of 25 specimens from southern Cameron County, Texas

(hence practically topotypes), about two-thirds have the forehead clear white; in the others it has distinctly a creamy suffusion, which in some specimens is conspicuously strong (*'castaneifrons'* Sennett). The white frontlet also varies in width, through the posterior feathers being often tipped minutely with black, and in a few there is an extremely narrow median line of black running forward from the black of the crown to the base of the culmen. Some 50 specimens or more from Nuevo Leon and Tamaulipas are exactly similar to Brownsville specimens as regards the forehead. In a series of 40 specimens from Hidalgo County (Hidalgo and Lomita Ranch on the Rio Grande), fifty miles above Brownsville, more than one-third have the white forehead more or less tinged with a creamy suffusion, often strongly so, and about one-fourth have black tips to a portion of the frontal feathers, or a fine black median line, or both. At points further north and west, as in Live Oak, Frio, and Concho Counties, the buffy suffusion increases in strength and frequency, and the black of the crest becomes paler and more restricted (typical *'castaneifrons'*). In a series of 14 specimens from Frio River (exact point not known but probably Uvalde Co.), one only has the forehead white; in the others it ranges from a pale creamy tint to ochraceous, with a reduced amount of black on the crest feathers. In the Bed County series all of the adults have the forehead more or less suffused, varying from buff to rusty-chestnut. (This series furnished the types of both *castaneifrons* and *texensis* of Sennett!). The black on the crown varies from dusky brown to nearly the normal amount of black in *atricristatus*.

Six specimens from Travis County all have the frontlet chestnut; in two the crest is black, in the others the crest is gray like the back, or mixed gray and black. In another specimen ("Brownsville," but locality unquestionably erroneous) the forehead is deep chestnut, divided mesially by a strong black line; the crest is gray.

Color of Crown and Crest.— In *B. bicolor* the crown and crest, as already said, are dark gray, distinctly darker than the back, but rarely showing any tendency to blackish; exceptional specimens show dark shaft-streaks, more frequently present in southern than in northern examples. A specimen from Hollis Hill, Florida, has each feather of the crest *broadly centered with blackish.* In specimens of *B. atricristatus* from Mexico and the Lower Rio Grande Valley the crest feathers are longer and the black is more intense and shining than in specimens from further northward in Texas, where the black becomes more restricted in area and less intense, and the crest feathers are relatively shorter. Also the whitish forehead becomes more strongly suffused with buff, markedly so in about 25 per cent. of the specimens examined.

Size.— In both *B. bicolor* and *B. atricristatus* there is a marked decrease

in size from the north southward, as in most other birds of northern origin. As in numbers of other birds of similar range, there is in *B. bicolor* relatively a slight increase in the length of the bill in southern birds as compared with northern birds. While Florida birds have the wing and tail each 5 to 7 mm. shorter than New Jersey birds, the culmen is fully as long or slightly longer than in the larger northern birds. *B. bicolor* appears to reach its maximum size in eastern Kansas (Fort Leavenworth, Council Grove, etc.), and an eastern Kansas race was long since provisionally named *Parus missouriensis* by Baird. The small Florida form has also been separated by Bangs as a subspecies *floridanus,* chiefly on the ground of its smaller size and relatively larger bill.

B. atricristatus reaches its maximum size in the northern part of its range, in southwestern central Texas, where it completely intergrades in size with *B. bicolor.* Although *B. bicolor* is much larger in the average than *B. atricristatus,* Texas and Florida specimens of *bicolor* are quite as small as the northern representatives of *B. atricristatus.*

As shown in the tables of measurements given below, in *B. bicolor* from northern New Jersey and Pennsylvania, the wing averages in 10 males about 82 mm. (78–85), and the tail about 74 mm. (73–80) in length, while in 16 males from northern Florida the corresponding measurements are: wing, 76 (71–78); tail, 67 (65–72). The average of 5 males from eastern Kansas is: wing, 83, tail, 75; of 8 males from San Antonio, Texas, wing, 80, tail, 74; 6 males from Lee County, Texas, average slightly smaller. In the females the corresponding measurements are about 3 to 5 mm. less for each locality.

In *B. atricristatus* (*sennetti* Ridgw. = *castaneifrons* Senn.) males from Concho, Jeff Davis (Fort Davis), Leon, Bexar, Uvalde, and Nueces Counties range in average length of wing from 76.5–77 (74–80), averaging slightly larger than *bicolor* from various central and eastern Texas localities, but with the maximum in individual specimens far overlapping the minimum in *bicolor.* In true *atricristatus* from the Lower Rio Grande Valley in Texas and the adjoining border of Mexico the average length of wing falls to 71–71.6, or about 5 mm. below the average in the northern form of *atricristatus.* In central Tamaulipas and central Nuevo Leon, there is a further slight decrease of 1–2 mm. in the average wing length (65–69, 15 males).

In specimens of mixed character, from Bee, Live Oak and Bexar Counties, the average is very close to the average of *atricristatus sennetti.* The length of the wing and tail at different localities is summarized in the subjoined tables, comprising 110 specimens of the former and 162 of the latter.[1]

[1] The measurements of specimens from the localities enclosed in brackets are from Ridgway's 'Birds of North and Middle America,' Part I, 1901, pp. 382 and 385.

MEASUREMENTS OF *Bœolophus bicolor* AND *B. atricristatus.*

Bæolophus bicolor.

Males, eastern localities.

	No. of specimens.	Wing.	Tail.
Morristown, N. J.	8	82 (78–85)	74.9 (73–80)
Beaver Co., Pa.	4	82.3 (81–83)	74.3 (74–75)
Circleville, Ohio	2	78 (75–81)	73 (72–74.5)
S. Ill. and S. Ind.	8	80 (77–82)	74.3 (71–77)
Washington, D. C.	8	79.3 (77–80.5)	74 (71–78)
Mitchell Co., N. C.	2	80 (79–81)	75 (72–81)
Frogmore, S. C.	1	80	73.5
Gainesville, Fla.	3	74 (73–76)	69.3 (67–71)
Rosewood, Fla.	1	78.5	72
Fort Myers, Fla.	2	72 (71–73)	65 (65–65)
[Florida.]	10	77.6	66.4
Clinton, La.	2	75.5 (75–76)	71.5 (71–72)
[Louisiana, Mississippi, and Alabama.	4	79.3	68.2

Males, western localities.

Council Grove, Kan.	2	84.3 (84–84.5)	76 (74–78)
[Eastern Kansas.]	3	82.5	73.3
Lee County, Texas.	6	79.3 (77–81)	71.3 (68–74)
San Antonio, Texas.	8	80 (77–82)	74.3 (71–77)
Matagorda Co., Texas.	1	78	70

Females, eastern localities.

Morristown, N. J.	2	77 (75–80)	72.5 (72–73)
Circleville, Ohio.	4	78 (73–80)	68.5 (67–79)
Wheatland, Ind.	3	76.3 (75–77)	69 (68–70)
Washington, D. C.	5	76 (75–78)	71 (71–72)
Summerville, S. C.	1	79	72
Kershaw Co., S. C.	4	76 (74–77)	69.5 (68–71)
Frogmore, S. C.	1	75	68
Augusta, Ga.	4	74.7 (72–76)	69.3 (69–72)
Gainesville, Fla.	3	74 (73–76)	69.3 (67–71)
Rosewood, Fla.	4	75.4 (74–78)	69.8 (65–76)
[Florida.]	8	76.4	67.9
[Louisiana.]	1	75	65

Females, western localities.

[Eastern Kansas.]	1	82	70
Lee Co., Tex.	4	75 (74–77)	66.5 (65–71)
San Antonio, Texas.	3	74	66.3 (64–72)

Bæolophus atricristatus.

	Males.		
[Central Texas.[1]]	10	77.1 (75–79.5)	66.9 (64.5–68.5)
Bexar Co., Tex.	3	74 (72–75)	68 (67–69)
Concho Co., Tex.	2	76.5 (75.5–77.5)	70.3 (69.5–73)
Travis Co. (Austin), Tex.	4	75.5 (73–78)	70 (68–72)
Jeff Davis Co. (Fort Davis), Tex.	3	77 (70–75)	69 (67–71)
Uvalde Co., Tex.[2]	8	76.3 (74–80)	70.4 (68–73)
Bee Co., Tex.[3]	10	76.5 (73–78)	69.7 (65.5–71.5)
Nueces Co., Tex.[4]	8	76 (74–77)	71.8 (69–74)
Kinney Co. (Fort Clark), Tex.	3	74.3 (73–76)	67.7 (65.5–71)
Webb Co. (Laredo), Tex.	5	74 (70–75)	69 (66–72)
Hidalgo Co. (Hidalgo and Lomita), Tex.[5]	14	70 (67–72)	65 (61–72)
Cameron, Co. (Brownsville and vicinity), Tex.	10	71.6 (68–76)	65.3 (61–68)
[Brownsville, Tex.]	9	70.8	61.9
Northern Nuevo Leon	5	71.4 (70–73)	66.2 (65–67.5)
Central Nuevo Leon	6	70.8 (68–73)	66.5 (63–69)
Central Tamaulipas	6	71.5 (65–75)	65.7 (60–70)
[Tamaulipas to Vera Cruz.]	5	69.5	58.3
	Females.		
[Central Texas.]	9	72.7 (70–76)	64.5 (61–69)
Bexar Co. Tex.	3	71 (70–73)	66.3 (66–67)
Concho Co., Tex.	2	75.4 (74.5–77)	69 (66–72)
Travis Co. (Austin), Tex.	1	72.8	66
Uvalde Co., Tex.	6	73.8 (68–74.5)	67 (65–69)
Bee Co., Tex.	6	75 (74–78)	66.5 (62–69)
Kinney Co. (Fort Clark), Tex.	3	71.3 (70–72)	66 (65–67)
Webb Co. (Laredo), Tex.	5	70.5 (69–73)	65.8 (63.5–67.5)
Hidalgo Co., Tex.	5	65.4 (63–67)	63 (62–64)
Cameron Co., Tex.	6	68 (66–72)	63.4 (60–70)
[Brownsville, Tex.	4	70.8	61.9
Central Nuevo Leon.	6	68 (66–70)	64.3 (62–67)
[San Luis Potosi.]	1	65.5	55.5

Summary and Conclusions.

In geographic variation the differences that characterize conspecific subspecies are differences of degree, affecting size or color, usually both. In the two or three thoroughly known cases of hybridity in wild North American birds, the differences (except in the matter of size), between the

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[1] *Bæolophus atricristatus sennetti* Ridgway.
[2] *Parus atricristatus castaneifrons* Sennett.
[3] *Parus atricristatus castaneifrons* Sennett, and *Parus bicolor texensis* Sennett, about an equal number of each.
[4] Labelled *P. a. castaneifrons* by Sennett.
[5] All labelled *Parus atricapillus* by Sennett, as are also all Cameron County specimens.

hybridizing species are radical, both in the pattern of markings and the color, as in the two hybridizing Flickers (*Colaptes*) and the two hybridizing Warblers (*Helminthophila chrysoptera* and *H. pinus*); in the case of the Grackles (*Quiscalus*) the conditions as to coloration are somewhat different there being a less striking difference in pattern and color. In the two species of *Bœolophus* there is again a radical difference in pattern, one having a black crest and a whitish frontal band, and the other a gray crest and a black frontal band.

These two species meet in Texas: on the coast, at the mouth of the Nueces River; in the interior along the 98th meridian, from the Nueces River northward, probably to the northern limit of the range of *B. atricristatus*. The line of contact of the two species coincides remarkably close with the junction of the humid and arid divisions of Texas, as shown by Mr. Vernon Bailey on his map of the Life Zones of Texas.[1] Well-marked 'intergrades' occur over apparently a rather narrow zone (apparently about 50 to 100 miles in width), trending nearly north and south, from Bee and Live Oak Counties to Lampassas County, or for a known distance of about 200 miles. Bee, Live Oak, Bexar, and Travis Counties are the only points from which, at present, material is available for examination; but similar conditions may be expected to occur along the junction of the ranges of these two species from Refugio,[2] San Patricio and Bee Counties to Young County, or for probably about 300 miles.

While these two species completely merge geographically, as already shown, as regards size and general coloration, both decreasing in size and becoming somewhat modified in other respects from the north southward, like hundreds of species of other birds inhabiting the same geographical areas, the radical distinctions furnished by the color of the crest and frontal band remain practically unchanged until the ranges of the two species are actually in contact. The final blending of the two is not along a line of very marked geographic intergradation, nor is the manner of final intergradation of a geographic character. The same localities furnish, at several known and quite widely separated points, birds of pure blood of both species, and intergrades having almost every possible combination of the strikingly dissimilar features of the two species. There are gray-crested and black-crested birds with a chestnut frontal band, paling nearly to whitish or darkened with blackish; and also birds with every kind of crest from gray to black: gray shaded with black, the gray and black about

[1] North American Fauna, No. 25, 1905, plate 1.

[2] James J. Carroll, in his 'Notes on the Birds of Refugio County, Texas' (Auk, XVII, 1900, p. 348) records *Parus bicolor texensis* Sennett as "very common" in Refugio County, and does not record from there either *bicolor* or *atricristatus*. This would imply that all the birds examined by Carroll during a four years' field experience "during the winter and spring" were intermediates or hybrids.

equally developed, and black with the feathers merely edged with gray, and clear black, the frontal band being in all more or less rufous; also occasional birds with the frontal band greatly reduced in width, or nearly obsolete.

After careful study of all the available material from Texas representing *Bœolophus bicolor* and *B. atricristatus* (about 200 specimens),[1] I accept Mr. Ridgway's view,[2] that the birds showing mixed characters are hybrids and not geographic intergrades.

Subspecies of the *Bœolophus bicolor-atricristatus* Group.

As already shown, there is about the normal amount of geographic variation in size and general coloration in both *B. bicolor* and *B. atricristatus*. It seems, however, too slight in *bicolor* to warrant its separation into subspecies, although the difference in size between northern and southern specimens is quite marked. The maximum size of *bicolor* appears to be reached in the northern part of its trans-Mississippi range, where also slightly paler coloration may be expected. But available material for examination from this region is at present lacking.

B. atricristatus presents about the same range of geographic variation in size as *bicolor*, with, however, rather more pronounced color differences; the northern form is not only much larger and grayer than the southern, but has a shorter crest, with the black area more restricted and duller, and it has, apparently, rather definite geographic limits — Texas, north of the Lower Rio Grande Valley, and from about Eagle Pass westward and northward. The type of *B. atricristatus* came from some point on the Rio Grande between Brownsville and Rio Grande City.[3] Mr. Ridgway (*l. c.*) has characterized this larger northern form under the name *Bœolophus atricristatus sennetti*, he claiming that Sennett's *Parus atricristatus castaneifrons* and *Parus bicolor texensis* were both based on hybrids, the former on four specimens and the latter on two specimens, all collected at the same time and place on the Aransas River, in Bee County, about 15 miles southeast of Beeville.[4] Later Mr. Sennett received a large number of birds from various parts of southwestern Texas which he labelled *Parus atricristatus castaneifrons*. This series covers the known range of Mr. Ridgway's sub-

[1] See *infra*, under 'Material Examined,' where the localities and character of the intergrades are stated in detail.

[2] Birds of North and Middle America, Part III, 1904, p. 386, footnote.

[3] Type locality, as given by Cassin, "Texas, upon the Rio Grande, discovered by Mr. John Woodhouse Audubon." An examination of J. W. Audubon's 'Western Journal: 1849–1850' (1906), Chap. II, shows that Audubon must have obtained the type somewhere below Rio Grande City.

[4] *Fide* Becham, Proc. U. S. Nat. Mus., Vol. X, 1887, p. 692, on the authority of the collector, John M. Priour.

species *sennetti*, so that the name *castaneifrons*, as used by Sennett on his labels, exactly equals the much later *sennetti* of Ridgway. Mr. Sennett labelled all of his Lower Rio Grande and Mexican specimens *atricristatus*, thus sharply discriminating between the two races.

Mr. Ridgway did not have Mr. Sennett's series for examination, not even his types of *castaneifrons* and *texensis*. As assumed by Mr. Ridgway, however, all these types are unquestionably hybrids, the male type of *castaneifrons* having the forehead bright chestnut and the black of the crest dull, much restricted, and mixed with gray; in the female the forehead is much duller and the crest merely blackish washed with gray. This being the fact, it is perhaps better to accept for the large northern race of *atricristatus* the name *sennetti* rather than *castaneifrons*.

Material Examined.

I am greatly indebted to the kindness of the authorities of the U. S. National Museum and the Bureau of the Biological Survey for a large part of the specimens recorded below, without the aid of which this investigation could not have been undertaken. I am also indebted to Dr. J. Dwight, Jr., for the loan of a number of important specimens used in the present connection.

The letters A, B, and N, at the left of the entries indicate the sources from which the material was received, as follows: A = American Museum of Natural History; B = Biological Survey; N = U. S. National Museum.

Under the heading, 'Specimens of Mixed Character,' many of the intermediate specimens are mentioned in some detail.

The total number of specimens examined is about as follows: Biological Survey, 92; U. S. National Museum, 101; American Museum of Natural History, 296. Total 489. They are divided by species and geographically as follows:

Bœolophus bicolor, from localities east of the Mississippi, 121; from localities west of the Mississippi, 5; from Texas, 39. Total, 165.

Bœolophus atricristatus atricristatus, from Texas, 82; from Mexico, 52. Total 134.

Bœolophus atricristatus sennetti. 88.

Bœolophus a. sennetti + *bicolor*. 102.

Bœolophus bicolor, from East of Mississippi River.

A.	Westchester, N. Y.	1	**B.**	Georgetown, S. C.	1
A.	Morristown, N. J.	13	**A.**	Summerville, S. C.	5
A.	Maplewood, N. J.	1	**A.**	Chester C. H., S. C.	1
A.	Erie, Pa.	2	**A.**	Aiken, S. C.	2
A.	Crafton, Pa..	1	**A.**	Frogmore, S. C.	2
B.	Beaver Co., Pa.	5	**A.**	Hobcaw Point, S. C.	1
B.	Fulton Co., Pa.	1	**N.**	Augusta, Ga.	3
B.	Bedford Co., Pa.	1	**N.**	Kershaw Co., Ga.	5
A.	Circleville, O.	6	**A.**	Gainesville, Fla.	12
N.	Wheatland, Knox Co., Ind.	4	**N.**	Lake Trafford, Fla.	1
N.	Mt. Carmel, Ill.	2	**A.**	Rosewood, Fla.	4
N.	Parkersburg, Ill.	1	**N.**	Big Lake George, Fla.	2
N.	Jacksonville, Ill.	2	**A.**	Hollis Hill, Fla.	1
N.	Bardstown, Ky.	1	**N.**	Fort Gardner, Fla.	1
N.	Lexington, Ky.	1	**B.**	Galton, Ala.	1
N.	Rockwood, Tenn.	4	**B.**	Chautauqua, Miss.	1
N.	Laurel, Md.	3	**N.**	Bay St. Louis, Miss.	2
A. N.	Washington, D. C.	14	**B.**	Belair, La.	1
N.	Gainesville, Va.	2	**A.**	Clinton, La.	2
B.	Cape Charles, Va.	1	**A.**	Madisonville, La.	1
A.	Mitchell Co., N. C.	6			

Bœolophus bicolor, from West of Mississippi River.

B.	Marble Cave, Mo.	1	**B.**	Savanna, Ind. Terr.	1
A.	Council Grove, Kans.	2	**B.**	Mt. Scott P. O., Okla.	1

Bœolophus bicolor, from Texas.

B.	Texarkana, Bowie, Co.	1	**N.**	Hemstead, Washington Co.	1
A.	Grigsby's Bluff, Orange Co.	3	**N.**	San Antonio, Bexar Co.	9
B.	Jasper, Jasper Co.	1	**B.**	Columbia, Brasoria Co	1
N.	Rice, Navarro Co.	1	**A.**	Brasoria County	1
B.	Sour Lake, Hardin Co.	1	**B.**	Matagorda, Matagorda Co.	3
B.	Waco, Mclennan Co.	2	**A.**	" " "	4
B.	Conroe, Montgomery Co.	2	**B.**	Inez, Victoria Co.	1
A.	Giddings, Lee Co.	6	**A.**	Victoria Co.	2

Bœolophus atricristatus atricristatus.

Texas.

B.	Brownsville, Cameron Co.	6	**A.**	Lomita Ranch, Hidalgo Co.	34
N.	" "	3	**B.**	" " "	1
A.	Cameron Co. (mostly from Brownsville)	16	**A.**	Hidalgo, Hidalgo Co.	7
A.	Rio Grande City, Starr Co.	11	**B.**	" "	1
B.	Paisano, Starr Co.	2	**B.**	Dimmitt Co.	1

Mexico.

A.	Boquillo, Nuevo Leon.	7	**A.**	Victoria, Tam.	1
A.	Boque Negro, "	1	**A.**	San Fernando River, Tam.	1
A.	San Pedro Mines, "	6	**A.**	Fernando de Presos, "	1
A.	Montemorelos, "	1	**A.**	Xicoteucatl, "	1
B.	Monterey, "	4	**A.**	Soto le Marina, "	1
A.	" "	3	**B.**	Camargo, "	1
A.	Rio San Juan, "	2	**B.**	Alta Mira, "	1
B.	Rodriguez, "	5	**B.**	Sabinas, Coahuila	1
B.	Cerro de la Silla, "	4	**B.**	Valles, San Luis Potosi	2
B.	Rio de Ramo, "	1	**B.**	Papantla, Vera Cruz	1
B.	Linares, "	1	**N.**	Mirador, "	1
B.	Matamoras, Tam.	1	**N.**	Mexico (Verreaux spec.)	1
B.	Victoria, "	3			

Bœolophus atricristatus sennetti.

(All from Texas.)

B.	Cotulla, La Salle Co.	3	**N.**	Medina Co.	1
B.	Ingram, Kerr Co.	2	**N.**	Boerne, Kendall Co.	1
B.	Del Rio, Valverde Co.	1	**N.**	Leon Springs, Bexar Co.	6
B.	Langtry "	1	**N.**	San Antonio, Bexar Co.	9
B.	Fort Davis, Jeff Davis Co.	4	**A.**	Nueces River (County ?)[1]	11
A.	" "	5	**A.**	Paint Rock, Concho Co.[2]	10
B.	Davis Mts., Reeves Co.	1	**A.**	Laredo, Webb Co.	12
B.	San Diego, Duval Co.	1	**N.**	" "	1
B.	Chisos Mts.	1	**A.**	Rio Frio (Uvalde Co. ?)[1]	13
B.	Locker's Rancho	1			

Specimens of Mixed Character (Central Texas).

N. San Antonio, Bexar Co. 10

Of 27 specimens from this locality, 9 are typical *bicolor*, 9 are fairly typical *atricristatus sennetti*, 5 approach more or less the '*texensis*' phase, 3 are '*texensis*,' and 1 is '*castaneifrons*.'

N. Leon Springs, Bexar Co., about 20 miles north-northwest of San Antonio . 1

Of 6 specimens, 5 are of the *atricristatus* type and 1 is a good '*castaneifrons*.'

N, A. Fort Clark, Kinney Co. 21

All are referable to *atricristatus sennetti*, except that about 25 per cent. have the frontal band too strongly suffused with rufous to be typical.

B. Cisco, Eastland Co. 13

All have black crests, but in most of them the black is dull and the feathers edged with gray, especially in the females, but also in some of the males; the forehead is more strongly suffused with brownish than is usual in the *atricristatus* group, and the posterior rows of feathers of the frontlet are conspicuously tipped with blackish. They agree with the large series in the Sennett collection labelled by him '*castaneifrons*.'

A. Corpus Christi, Nueces Co. 1

[1] Labelled *castaneifrons* by Sennett.
[2] Part labelled *castaneifrons* and part *atricristatus* by Sennett.

Frontal band white; crest feathers blackish, more or less edged with gray. Mr. Chapman collected this specimen and reported seeing one *bicolor*. (Bull. Am. Mus. Nat. Hist., III, 1891, 327.)

B. Mouth of Nueces River 1

Frontal band very narrow, strongly chestnut; crest feathers with the black restricted and edged with gray.

A. Bee County, near Beeville 26

There are 16 adults and 10 in first plumage. Of the adults, 12 are labelled as *Parus bicolor texensis* by Mr. Sennett, and 4 as *P. atricristatus castaneifrons*. They include the original 6 specimens on which *texensis* and *castaneifrons* were based, and 10 others received later. The 10 young birds were all identified by Mr. Sennett as *texensis*. The 4 original specimens of *castaneifrons* have the black of the crest much restricted and dull, the feathers more or less gray-edged, especially in the females. In two of them the forehead is bright reddish; in one (sexed ♂), it is buffy white, as pale as in many specimens of true *atricristatus*, the crest small and dull blackish; in the other (sexed ♀) the forehead is rusty buff and the black of the crest feathers is greatly restricted and dull grayish black in general effect.

In the 10 adult '*texensis*' specimens the crest is gray washed with blackish, faintly in three of the specimens; the forehead is chestnut in all, varying from rather strong clear chestnut to pale chestnut, in one suffused with blackish, in two very pale rusty chestnut. The 10 young birds ('*texensis*' Sennett) have the whole crown faintly dusky, but decidedly darker than the back (as in all young birds of the *bicolor-atricristatus* group) and there is generally a very narrow blackish frontlet, with a slight buffy suffusion.

In other words, the whole Bee County series of adults consists of 'intermediates,' showing a wide range of individual variation. In some there is only the merest trace of blackish in the crest, grading up to a crest as full and as black as in specimens from other localities that would be unhesitatingly referred to Ridgway's *B. atricristatus sennetti*. In none is the forehead black, but in one the 'chestnut' suffusion is no greater than in some Rio Grande specimens of true *atricristatus*.

A. Travis County (Austin and vicinity) 6

In this series of 6 specimens (2 from Dr. Dwight's Coll.), no two are very nearly alike. Two may be described as nearly typical *bicolor* with the frontal band narrow and deep reddish chestnut instead of black. Another has the forehead dingy gray tinged with rusty mesially and a dull blackish crest. A fourth has the frontal band of normal width (twice as broad as in the others), dull chestnut tinged with dusky, especially on the posterior third; the crest is gray with all the feathers broadly centered with blackish. A fifth has a bright reddish narrow frontal band, and the crest suffused with blackish. The other has the frontal band almost obsolete, and of a dingy buffy gray; the crest is full and black, about as in average examples of *B. atricristatus sennetti*.

A. "Brownsville," Texas (locality obviously erroneous; Lawrence Coll.) . 1

Crest and general coloration as in *bicolor*; frontal band broad, bright reddish chestnut, with the feathers conspicuously tipped with black. The chestnut of the frontal band greatly predominates over the black; otherwise the specimen is *bicolor*, and was so identified by Mr. Lawrence.

B. Seguin, Guadelupe Co. 1

A female with the black of the crest much restricted and the frontal band buffy, the feathers black-tipped.

A. Paint Rock, Concho Co., Texas 2

Two specimens in a series of 10 have the forehead chestnut and the crest feathers gray-edged.

A. Lampassas Co., Texas 1

A yellowish brown frontal band and the crest feathers much edged with gray.

A. Rio Frio (county not stated) 13

In a series of 13 specimens, the forehead is yellowish brown in most of them, and the black of the crest is rather restricted and the feathers often gray-edged, particularly in the females.

A. Live Oak Co., Texas 5

All but one have the forehead buff, strongest in the male; crest in the male with the black restricted and some of the feathers gray-edged; crest in the females dull blackish gray.

59.81(78.9)

Article XXIII.— A COLLECTION OF REPTILES AND AMPHIBIANS FROM SOUTHERN NEW MEXICO AND ARIZONA.

By Alexander G. Ruthven.

During the summer of 1906 the writer made a trip to southwestern United States for the purpose of obtaining a collection of the terrestrial cold-blooded vertebrates of that region for the American Museum of Natural History. The work was carried on during July and August, and at two points — Alamogordo, New Mexico, and Tucson, Arizona.

In all about 1,000 specimens were obtained, besides many notes on the habitat relations of the different forms. Special effort was made to secure the latter as the writer holds the point of view so ably stated by Gulick:[1] "Inquiries leading to the discovery of bionomic laws have usually been first suggested by observing the relations under which the organisms present themselves as distributed in nature; but after we have once recognized the fact that these relations are the result of the constant interaction between organism and organism, and between the organism and the physical environment, it becomes necessary to make a full classification of the different forms of interaction that tend to modify the species. A systematic and thorough use of this method will, I am convinced, throw light on many problems, correcting many partial and incomplete theories. We may also hope that a careful examination of the different forms of interaction will, in some degree, lessen the danger of attributing exclusively to one form of interaction results that are due to several forms of action. And having discovered that similar results are produced by different forms of action, we are next led to seek for the underlying principle in which they agree." It will be noted that two forms of interrelations are recognized in the above quotation ("the interaction between organism and organism and between the organism and the environment"), both of which may give rise to isolation and racial divergence. The following paper is the result of an endeavor to gather data bearing upon the interrelations between the reptiles and amphibians of the Southwest and their environment.

There is no reason to believe that reptiles and amphibians are less influenced by environmental conditions than are other groups. Indeed, with their limited powers of migration they must be more so than many other forms, and besides the geographic isolation that necessarily attends a

[1] Gulick, Evolution Racial and Habitudinal, p. 10–11.

close interrelation of organism and environment we may expect to find nearly related species associated with different environmental complexes, or in the same habitat when the habits are sufficiently different, for both

Fig. 1. Bottom of Box Cañon, Sacramento Mountains (altitude 6,000 feet). The Vegetation consists of *Pinus ponderosa*, *Abies concolor*, Ash, Willow, etc.

of these phases of environmental isolation are like the geographic in that they are favorable factors in the production of divergent racial groups. By determining, therefore, the interrelations between the different forms

and the environmental conditions with which they are found associated, clues may be obtained to the centers of origin, routes of migration, genetic relationships, and possibly some of the causes of divergence.

In carrying out this investigation, however, it must be borne in mind that the problem is a dynamic one. As has been elsewhere stated[1] "the environmental factors are the same as the geological factors in the belt of weathering. Each of these factors is the resultant of various processes (composed in turn of physical forces, heat, light, etc.) which when not in equilibrium tend to become so. The adjustment of these processes to each other brings about changes in the conditions which can only approximately cease when they approach an equilibrium, as, for example, when the topography has been reduced to a base-leveled plain covered by a layer of residual soil. The conditions in habitats where the processes are not in equilibrium are thus being constantly changed in the direction of other habitats in which they have more nearly reached an adjustment, and a succession of societies occurs that only ceases when the processes have become approximately adjusted to each other. The forms that are adapted to the adjusted conditions will constitute the climax society. It is necessary to here emphasize the importance of the organic factor; this must also become adjusted to the others for the entrance of new forms into a region may greatly disturb the equilibrium of its societies." Thus, owing to the fact that the conditions are not stable, in order to interpret the present conditions it is necessary to determine the history of the environment. With these points in mind the work upon which this paper is based was carried on as follows:

1. Two separate regions were explored in order to furnish grounds for comparison.

2. Each region was first covered by a brief reconnaissance in which the different habitats were noted.

3. Typical and accessible points in these habitats were then designated as stations, and the physical conditions and characteristic plants of each were listed.

4. The reptile and amphibian life of each habitat was determined by careful and persistent collecting, and each specimen was numbered and catalogued with the station number and such data as could be secured on habits, including an examination of the stomach contents in as many cases as possible.

The writer fully realizes that the results of the present work are very incomplete. They are necessarily so, however. In the first place it is

[1] Ruthven, An Ecological Survey in the Porcupine Mountains and Isle Royale, Michigan. Ann. Rept. Geol. Surv. Mich., 1905, 43.

Fig. 2. South side of Box Cañon, Sacramento Mountains (altitude 6,000 feet). Piñon-Cedar association. The conspicuous plants are *Pinus edulis*, *Juniperus monosperma* and *J. pachyphlæa*. *Sceloporus consobrinus* occurs commonly in this habitat.

Fig. 3. Characteristic Piñon tree (*Pinus edulis*), in the Piñon-Cedar association.

Fig. 4. Typical growth of cedar (*Juniperus monosperma*) in the Piñon-Cedar association.

Fig. 5. Foothills of the Sacramento Mountains east of Alamogordo, N. M. Sotol-Ocotillo association. *Crotaphytus collaris baileyi* was found here.

often difficult in the case of reptiles to determine the characteristic forms of a habitat for, owing to their secretiveness, many common forms are often quite as apt to be overlooked as are the rarer ones. Then again while a number of systematists have applied these methods in a general way to other groups, with good results, the literature on the reptiles and amphibians still consists principally of annotated lists which ignore for the most part all environmental factors with the exception of the geographic.[1] Little data for comparison is therefore at hand, and in many instances one can only state the facts observed in the hope that they may serve as a basis for future work.

I desire, first of all, to acknowledge my indebtedness to the American Museum through Dr. H. C. Bumpus and Dr. W. M. Wheeler for the opportunity of carrying on this work, and to these gentlemen in particular, whose interest and coöperation made the trip a very pleasurable one. I am also under great obligations to Prof. Volney M. Spalding of the Desert Botanical Laboratory of the Carnegie Institution, who spent the early part of the summer at Alamogordo, and who very generously placed at my disposal the general results of his work on the local distribution of the flora of that region. I wish also to express my indebtedness to my assistant Mr. Gneomar von Krockow, of the American Museum, for his efficient service; to Mr. A. F. Zimmer of Chicago, who accompanied the party throughout the season entirely at his own expense, contributing many specimens to the collections, and to Prof. F. E. Lloyd, of the Desert Botanical Laboratory, and Prof. J. J. Thornber, of the University of Arizona, for many specimens, and much valuable information relative to the distribution of the flora and fauna about Tucson.

In the identification of several species I gratefully acknowledge the assistance of Dr. Leonhard Stejneger and Miss Mary C. Dickerson.

General Environmental Conditions.

Physiographic Features.— The topography of Arizona and New Mexico is dominated by the same feature — the high plateau with its two parietal series of broken mountain chains, that here replaces the lofty ranges of the Rocky Mountains. This plateau, which is bounded approximately by the contour line of 5,000 feet, is continuous with the high plateaus that abut against the eastern and western flanks of the Rocky Mountains, and forms

[1] Instances are numerous where the specimens in a collection from a given locality are labeled merely with the name of the principal neighboring town, fort, etc., when they may have been taken miles from the actual locality given and in many habitats.

with them a general plateau region. This feature is bordered on the south and west by a lower plateau between 3,000 and 5,000 feet, made up of short ranges and intermontane basins, and may be known as the Proplateau.[1] Extending northward from the Mexican Plateau with which it is continuous, the Proplateau pushes into southern Arizona, New Mexico and western Texas to the High Plateau, and follows along the margin of the latter as a narrow bench through Arizona into southern and western Nevada. In several places (the valleys of the Pecos and Colorado, and the bolson plains of the Trans-Pecos region) it penetrates the High Plateau region in long, narrow indentations.

As before stated the Proplateau is bounded by the 3,000 foot contour. In the United States its eastern margin is the Pecos valley, where it overlooks the Prairie region of central Texas, which falls away in elevation to 500 feet near the ninety-eighth meridian. Its western margin in the United States lies between the one hundred and tenth and one hundred and eleventh meridians, where it adjoins the desert plains about the lower parts of the Gila and Colorado rivers (Sonoran Desert) which also descend to a low elevation.

Climatology.— The climate of the different topographic divisions outlined above is distinctive. The Prairie region of Texas is semi-arid. The precipitation varies from about 15 inches on the western border to 40 inches at the ninety-eighth meridian. According to Hill[2] the seasonal distribution of rainfall in this region is determined by the overlapping of the Gulf and Sonoran types, "so that in these provinces there are usually two epochs of maximum rainfall, in May and September, respectively, and sometimes a third in June."

The desert plains of southwestern Arizona are, on the other hand, exceedingly arid. The mean annual temperature is above 65°, and as the humid air from the vapor zone in the Gulf of California is carried eastward by the prevailing westerly winds, so little moisture is precipitated that "upon this low plain the rain records approximate the absolute minimum of the world."[3] As it ascends to the Proplateau, High Plateau, and mountain summits, however, where the temperature is progressively lower, the moisture is condensed and precipitated, and the conditions become less arid. Thus the Proplateau has an annual precipitation of 10–15 inches, the High Plateau 15–20 inches, and the mountain summits (above 7,000 feet) over 20 inches.

The same type of rainfall — the Sonoran — prevails throughout the

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[1] Greeley, House Ex. Doc., 2d Sess., 51st Cong., XXXVIII, 303.
[2] Physical Geography of the Texas Region. Topog. Atlas U. S., 11.
[3] Greeley, Climate of Arizona. House Ex. Doc. XXXVIII, 304.

Fig. 6. Details of the Sotol-Ocotillo association. The Sotol, Ocotillo and various other Yuccas and Cacti may be distinguished.

Fig. 7. Alluvial slope east of Alamogordo, N. M. Creosote bush association. The only shrub in the foreground is the Creosote bush. *Cnemidophorus melanostethus* is practically confined in this habitat.

Fig. 8. Arroyo on the alluvial slope east of Alamogordo, N. M. Note the Ocotillo and Sotol along the banks and the Creosote bush in the background, showing that the flora of the foothills is carried well down into the Creosote bush association along the arroyos. *Cnemidophorus gularis* was found in this habitat.

Fig. 9. Central depression west of Alamogordo, N. M. Atriplex association. The principal bush in this habitat is *Atriplex canescens*. The eastern margin of the White Sands may be seen in the distance. The characteristic lizard is *Crotaphytus collaris baileyi*, although *Cnemidophorus sexlineatus* is also common.

Proplateau region in Arizona and New Mexico. There are two rainy seasons, the general rains of winter, and the violent showers of the summer months. Generally speaking, the former begin in Arizona in December and cease in February; the latter beginning in July and ending in September. In New Mexico the winter rains last from January to April, the summer rains from the middle of June or the first of July to October.

In this general region, therefore, there may be distinguished five general sets of environmental conditions, differing in respect to their topography and climate and grading into each other at the margins. They are: 1st, the Prairie region of Texas; 2d, the Desert plains of southern California, Arizona, and Nevada (Sonoran Desert); 3d, the Arid plains (including the mountain slopes below 5,000 feet) of the Proplateau; 4th, the High Plateau, including the mountain slopes of the Proplateau region between 5,000 and 7,000 feet; 5th, the higher summits between 7,000 and 10,000 feet.[1]

Alamogordo, New Mexico.

General Geography.— The region about Alamogordo was explored first. This locality is situated about half way up the Hueco bolson, one of the series of four parallel bolsons that carry the conditions of the arid plains of the Proplateau region well into the High Plateau. This feature is briefly described by Hill[2] as follows: "One of the most extensive and characteristic bolsons of the Trans-Pecos region is that lying between the Oscuro group on the west and the Hueco and Sacramento chains on the east, in southern New Mexico and extreme western Texas. This vast expanse of level plain extends through two degrees of latitude, from just south of the thirty-fourth parallel southward to the Rio Grande between Fort Hancock and El Paso. It is 40 miles wide at its northern end and broadens to 90 miles at its southern border along the Rio Grande.

"On all sides this bolson is inclosed by high mountain blocks or mesas. The mountainous perimeter includes the Sierra Blanca, Hueco, and Sacramento ranges on the east, the Franklin, Organ, and San Andreas blocks on the west, and unnamed Mexican Mountains on the south. At its north end is the Mesa Jumanes, dividing it from the Sandoval Bolson. A bench-like mesa projecting from the Sacramento Mountains is also shown on its eastern border.

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[1] In the Sacramento range and on the plateau, there are a number of summits which attain a greater elevation than 10,000 feet and support a boreal biota similar to that of the Rocky Mountains and northern North America. As these peaks could not be examined the habitat will not be discussed in this paper.

[2] Physical Geography of the Texas Region. Topog. Atlas U. S., 9.

"Although apparently level, this plain slopes southward, according to the profile of the El Paso and Northern Railroad, from 4,500 feet at its northern end to 3,500 feet at its southern end, having an approximate gradient of 7 feet per mile."

At Alamogordo the plain itself has an elevation of about 4,000 feet in the middle and rises gently toward the margins. The rim of the basin is formed by the Sacramento mountains on the east, and the San Andreas range on the west, both of which rise abruptly from the plain. The former have here an altitude of 9,000 feet, but the latter do not attain a much greater height than 7,000 feet.[1]

Description of Habitats.[2] — Undoubtedly one of the most potent factors in differentiating the environmental conditions in this region is the physiographic, as it profoundly affects both the climatic and edaphic conditions.

A comparison of the available records of Alamogordo and Cloudcroft shows that a marked decrease in precipitation and increase in temperature takes place between the mountain summits and the plain, which is accompanied by an increase in aridity. Owing to an abundant rainfall, the higher elevations (above 7,000 feet) are clothed with a dense forest growth, that has formed a layer of humus and holds a layer of residual soil. The vegetation of this habitat consists of such coniferous types as *Abies concolor*, *Pinus ponderosa* and *Pseudotsuga douglassi*, with scattered groves of oak and maple.

Below the contour line of 7,000 feet (approximately) the vegetation becomes more and more open, and the slopes exposed to the forces of denudation have become deeply dissected into steep-sided cañons and devoid of all but a thin covering of stony soil. The flora of this habitat is composed principally of low trees, such as *Pinus edulis*, *Juniperus pachyphlœa* and *Juniperus monosperma*, associated with a few cacti and yuccas (Figs. 2–4). On the floor of the larger cañons, however, where there is less exposure and more soil, the flora consists of forms of the coniferous forest of the summit (*Pinus ponderosa*, *Pinus concolor*, Poison Ivy, Virginia Creeper, etc.) which push down into the Piñon-Cedar zone in long tongues (Fig. 1).

Below 5,500 feet the slopes and cañons possess only a meager flora of low xerophytic forms, the slopes are swept bare except for a thin veneer of stony waste, the streams are small or transient, and the cañons strewn with large bowlders or floored by exposures of the bed rock. The characteristic vegetation consists of the Sotol, Ocotillo, and a number of yuccas and cacti (Figs. 5–6).

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[1] The San Andreas Mountains could not be explored on this trip, but Mr. Edwin Walters of Alamogordo, who has been over the region, informed us that the conditions on this range are the same as those of the Sacramentos below 7,000 feet.

[2] See also MacBride, Science, N. S., XXI, 90–97.

Fig. 10. Easternmost dunes of the White Sands west of Alamogordo, N. M. The steep slope (which is the lee slope) of the dunes indicates that they are advancing on the Atriplex association which is shown in the foreground. *Sceloporus consobrinus*, *Cnemidophorus sexlineatus* and *Holbrookia maculata flavilenta* were found on the face of this dune.

Fig. 11. General view of the White Sands west of Alamogordo, N. M. Sumac-Yucca association. The vegetation consists of *Rhus trilobata*, *Yucca radiosa*, Lavender and *Atriplex canescens*. The characteristic reptile of this habitat is *Holbrookia maculata flavilenta*.

During heavy rains the cañons are filled with torrential streams that rush out onto the desert floor and through the dry arroyos to form ephemeral lakes in the central depression. As they leave the cañons the coarser part of the material constituting their load is deposited as alluvial fans of stony material, that coalesce, forming a graded slope along the margin of the plain. The flora of this slope is very characteristic, as the dominant and one might almost say the only plant is the Creosote bush, which covers it from top to bottom with a dense growth (Fig. 7). On the stony soil near the top this flora becomes much diluted with the forms of the slopes, which push still

Fig. 12. Characteristic sink in the White Sands. The flora is composed principally of grasses and other low forms, *Atriplex canescens* also being present. The only reptile found in these bottoms was *Cnemidophorus sexlineatus*.

farther down in the arroyos (Fig. 8), and toward the bottom with those of the adjacent plains association, but these intermediate zones are so narrow that at a little distance the association appears sharply defined.

The finer material is carried out on the plain, and the salts largely to the central part of the basin. When the rains cease the streams on the desert floor and the lakes in the central depression rapidly disappear, and the soil dries out into a light pulverulent loam that increases in salinity toward the center of the basin. At the foot of the alluvial slopes the flora consists principally of the Mesquite (with considerable Crucifixion thorn), except

Fig. 13.

Fig. 14.

Figs. 13 and 14. *Yucca radiosa* and Lavender, above, *Rhus trilobata*, below, acting as dune holders on the White Sands. *Holbrookia maculata flavilenta* is found most commonly about such clumps of vegetation.

Fig. 15. Mesa west of the Santa Cruz River at Tucson, Ariz. Suaharo-Ocotillo association. Showing the characteristic plant of this habitat, the Suaharo. The small trees in the background are Palo verde.

Fig. 16. Plains east of Tucson, Ariz. Creosote bush association. The dominant shrub is the Creosote bush. The characteristic lizards of this habitat are *Cnemidophorus melanosthethus* and *Sceloporus magister*.

about the salt spots, where the principal forms are Allenrolfia and Atriplex. This vegetation prevails from the foot of the marginal slope, to a point about five miles to the westward, where it is replaced, owing probably to the increased salinity of the soil, by a flora consisting of the forms which margin the salt spots in the mesquite zone. This habitat occupies the central and lowest part of the basin. The soil is fine and strongly impregnated with salts. The vegetation consists of low forms, principally *Atriplex canescens*, associated with Suaeda, Sporobolus, and other low halophytic forms (Fig. 9).

In the central depression are situated the famous White Sands which cover an area of several hundred square miles on the western side of the plain, their eastern limit being marked by the steep faces of a long line of dunes in the central depression, about 12 miles west of Alamogordo (Fig. 10). They consist of shifting dunes of fine white gypsum sand, with intervening depressions (Figs. 10–14). They are said to owe their origin to the disintegration of exposed gypsum beds on the floor of the plain,[1] and are moving eastward on the desert floor under the influence of the prevailing westerly winds. The sand itself is composed principally of calcium sulphate,[2] and being soft and fine packs well, forming compact surfaces except on the lee slope of the dunes. In color it is a dull white that in the intense light of the desert takes on a buff or even pinkish tint.

Obtaining the minimum precipitation and possessing a porous, saline, and very unstable substratum, the White Sands form by far the most severe habitat in this region. Nevertheless they support a meager flora, that struggles to maintain a foothold, giving rise to the usual forms of wandering, captive and rejuvenated dunes.

Directly west of Alamogordo, and on the eastern margin of the White Sands is a large salina (Lake Walters) which is apparently perennial. It covers a roughly estimated area of two or three square miles, about one-fourth of which lies within the area of the White Sands. It is shallow and very strongly saline, and has a bottom composed of fine silt; the shores are covered with a layer of encrusted salts. During the summer months the rainfall is not sufficient to counteract the evaporation, and wide areas of mud are exposed about the shores.

The depressions within the White Sands appear to have the same level as the floor of the desert. They are usually dry, but those that extend inward from the end of Lake Walters contain occasional water holes in which the water is very alkaline. The vegetation of these bottoms consists of a low and comparatively dense growth of grasses and other low forms (Fig. 12), while on the dunes the flora consists almost entirely of a very scat-

[1] Herrick, The Geology of the White Sands of New Mexico, Jour. Geol., VIII, 123.
[2] Coville and MacDougal, Desert Botanical Laboratory of the Carnegie Institution, 9.

tered growth of *Rhus trilobata, Yucca radiosa,* Atriplex and Lavender, species that, with the exception of *Rhus trilobata,* are also found in the Atriplex association. These plants act as dune holders, *Rhus trilobata* probably being the most successful[1] (Figs. 13–14).

List of Stations.

Station I. Cloudcroft, N. M. Altitude 8,650 feet. Pine-Spruce association.
Station II. Between Pinto and Highrolls, N. M. Altitude 6,500 feet. Piñon-Cedar association. (Figs. 2–4.)
Station III. Foothills east of Alamogordo, N. M. Altitude 4,500 feet. Sotol-Ocotillo association. (Figs. 5–6.)
Station IV. Alluvial slope east of Alamogordo, N. M. Creosote bush association. (Fig. 7.)
Station V. Floor of Hueco bolson from Alamogordo to the White Sands inclusive.
Substation 1. Margin of plain, about Alamogordo. Mesquite association.
Substation 2. Central depression. Atriplex association. (Fig. 9.)
Substation 3. White Sands, Sumac-Yucca association. (Figs. 10–14.)

Tucson, Arizona.

General Geography.— This locality is situated in southeastern Arizona, a little to the north of the junction of the 32d parallel with the 111th meridian. It marks approximately the western limit of the Proplateau region, and the eastern margin of the Sonoran Desert in this latitude. The same broad topographic features prevail in this region as at Alamogordo and elsewhere in the Proplateau region — a low plain between parallel mountain chains.

Description of Habitats.— Here as elsewhere in the Proplateau region the mountains receive most of the rainfall. The summits, where high enough, are clothed with coniferous forests with a subjacent zone of Piñon and Cedar. These habitats could not be explored.

Below the Piñon-Cedar zone, owing to the increased aridity, the slopes are covered by a sparse flora of such xerophytic forms as the Sotol, Ocotillo, and various yuccas and cacti, the Suaharo being a conspicuous form. Dry cañons were not investigated but probably support a flora similar to that of the slopes. Sabino Cañon, in which there is a perennial stream, contains, below the Piñon-Cedar zone, a flora of shrubs and trees.[2]

[1] Lake Walters would be considered as a separate habitat, were it not for the fact that this paper concerns itself primarily with reptiles. The flora about its shores is distinctive, as is also its aquatic biota.

[2] Prof. Thornber has very kindly furnished me with the following list of the more characteristic trees and shrubs that occur in the lower part of Sabino Cañon: *Populus fremontii wislizeni, Platanus racemosus, Quercus oblongifolia, Quercus arizonica, Fraxinus velutina, Salix nigra, Salix bonplandiana, Celtis reticulata, Juglans rupestris, Rhamnus californica tomentella, Vitis arizonica, Dodonara viscosa, Coursetia microphylla.*

Fig. 17. Characteristic growth of the Cholla in the Creosote bush association on the plains about Tucson, Ariz. These Cacti are frequented by *Sceloporus magister*.

Fig. 18. Riparion vegetation along the Santa Cruz River at Tucson, Ariz. Willow-Poplar association. The trees are willows and poplars. This is the habitat of *Cnemidophorus gularis*, *Sceloporus clarkii* and *Uta ornata* on the plains.

Below an elevation of 3,000 feet a broad inclined bench of stony waste leads down from each range to the plain.[1] These slopes are elaborately dissected by branching arroyos, and are covered by a flora consisting principally of the Ocotillo, Sotol, Palo verde and various cacti and yuccas, with a slight infusion of plains forms (Creosote bush and Chollas, Fig. 15.) The larger arroyos are U-shaped, and contain a flora dominated by the Mesquite flanked by the Creosote bush on the slopes. In the smaller ones the vegetation is composed principally of the forms of the hills, with a narrow fringe of Cat's-claw tree, Palo verde and Mesquite on the immediate margin of the stream bed.

Fig. 19. Bed of Santa Cruz River at Tucson, Ariz. (The trees have been mostly removed from the banks at this place.) *Rana pipiens* is found commonly along the margin of this stream.

The plain which lies at the foot of the mesas has an altitude of about 2,500 feet. It is covered by a loose coarse soil, and supports a flora dominated by the Creosote bush and several arborescent Opuntias (Figs. 16–17). The former is so abundant and characteristic of the plains in this region as to have given to them the name of Greasewood plains. The feature differs from the plains at Alamogordo in being drained, so that there is no central depression or salinas.

The plain is traversed by numerous shallow sandy washes which are margined by Cat's-claw tree and Mesquite, but there are but three larger

[1] While similar in structure these detrital formations differ from the alluvial slopes at Alamogordo in that they have not been formed in the present geographic cycle. Their origin has been discussed by Ransome (U. S. Geol. Surv., Professional Paper, No. 12.).

streams in the vicinity of Tucson, the Santa Cruz River, Rillito Creek, and Pantano Wash, the last two being tributary to the former. The Santa Cruz River at this point is mostly perennial and is attended by three distinct floras, (1) an aquatic, (2) a marginal association composed of trees and bushes (Willows, Poplars and various shrubs), Fig. 18, (3) a flood-plain flora largely dominated by the Mesquite.[1] Nearly the same floras exist along Rillito Creek as along the Santa Cruz River, although modified by the greater aridity. The stream is not perennial so that an aquatic flora is wanting, and the trees found along the banks are few and scattered. The Mesquite zone is present, however, extending from the margin of the stream bed well onto the plains on the one hand, and on the other into the larger arroyos on the mesa that flanks the Santa Catalinas.

Pantano Wash is a wide arroyo, dry during the summer except after heavy showers. Both the aquatic and marginal floras are wanting, but there is a narrow Mesquite zone along its banks. The reptile fauna in this habitat was found to be identical with that of the surrounding plains, with which it may be considered.

List of Stations.

Station I. Plain north, east and south of Tucson.
- Substation 1. Plain proper. Creosote bush association. (Figs. 16–17.)
- Substation 2. Sandy washes. Acacia association.

Station II. Santa Cruz River from Tucson to a point about five miles to the southward.
- Substation 1. The stream. Association of aquatics. (Fig. 19.)
- " 2. Banks. Willow-Poplar association. (Fig. 18.)
- " 3. Flood plain. Mesquite association.

Station III. Rillito Creek, north of Tucson.
- Substation 1. Stream bed.
- " 2. Banks. Willow-Poplar association.
- " 3. Flood-plain. Mesquite association.

Station IV. Mesa and foothills northeast of Tucson Mountains, west of Tucson.
- Substation 1. Hills. Suaharo-Ocotillo association. (Fig. 15.)
- " 2. Slopes. Creosote bush association.
- " 3. Bottom of arroyos. Acacia association.

Station V. Alluvial slopes southwest of Santa Catalina Mts., northeast of Tucson.
- Substation 1. Hills. Suaharo-Ocotillo association.
- " 2. Slopes. Creosote bush association.
- " 3. Bottom of arroyos. Acacia association.

Station VI. Lower part of Sabino Cañon.
- Substation 1. Stream. Association of aquatics.
- " 2. Bottom of Cañon. Willow-Poplar association.

[1] Most of the arable land in this region along the Santa Cruz River, and about Tucson, the original plants have been mostly removed so that this zone may now very appropriately be called the zone of cultivated weeds, as suggested to me by Prof. Spalding. In our collecting, however, we confined our attention to localities where original conditions still prevail.

Annotated List.

SALIENTIA.

Scaphiopus couchii *Baird.*

Scaphiopus couchii Baird, Proc. Acad. Nat. Sci. Phila., 1854, 62.— Baird, U. S. and Mex. Bound. Surv., II, 1859, 28.— Cope, Proc. Acad. Nat. Sci. Phila., 1863, 52.— Cope, Bull. U. S. Nat. Mus., I, 1875, 32.— "Brocchi, Miss. Sci. Mex., Batr., 1881, 26."— Boulenger, Cat. Batr. Salient. Brit. Mus., 1882, 434–435.— Yarrow, Bull. U. S. Nat. Mus., XXIV, 1883, 25, 177.— "Belding, West Am. Sci., III, No. 24, 1887, 99."— Cope, Bull. U. S. Nat. Mus., XXXIV, 1889, 301–302.— Van Denburgh, Proc. Calif. Acad. Sci., Ser. 2, V, 1895, 558–559.— Dickerson, The Frog Book, 1906, 57–59.

Scaphiopus varius Cope, Proc. Acad. Nat. Sci. Phila., 1863, 52–53.—Cope, Bull. U. S. Nat. Mus., XVII, 1880, 29, 44, 46.— "Brocchi, Miss. Sci. Mex., Batr., XXIV, 1881, 27."

Scaphiopus varius varius Cope, Bull. U. S. Nat. Mus., I, 1875, 31.— Yarrow, *ibid.*, XXIV, 1883, 25, 177.

Scaphiopus couchii varius Cope, Proc. Acad. Nat. Sci. Phila., 1866, 313.— "Garman, Bull. Essex Inst., XVI, 1884, 1, 46."— Cope, Bull. U. S. Nat. Mus., XXXII, 1887, 12.

Locality.— A number of specimens of this Spadefoot were taken at Tucson, where it is apparently a common form.

Description of Specimens.— These specimens have the coarsely tuberculate skin, obscure parotids and rather distinct tympanum characteristic of *S. couchii.* Color above dull brownish yellow to bright greenish yellow, with an irregular network of brown bars. These may be broad and fewer with broad interspaces, or narrow and numerous with smaller light interspaces. Tubercles on the back (except between the hind limbs) black, those on the sides, and on the back between the hind limbs bright greenish yellow. Color of limbs above, as the dorsal surface except that the dark markings are roughly arranged as cross bars. Under surfaces white. Outer sole tubercle and occasionally the tips of the fingers and toes brownish black. Throat of the males not black.

Habitat Relations.— Six individuals (three males and three females) of this toad were found in a small pool on the flood-plain of the Santa Cruz River (Mesquite association), on August 1. They were breeding, and during the fertilization of the eggs the female was clasped firmly about the inguinal region by the male who kept up a constant singing. The pool was small and shallow, owing its origin to a few showers that had occurred previous to this date, one the night before. Five days later the pool had become entirely dry and hundreds of tadpoles were dying in the mud.

The transient nature of the water bodies on the plains makes it necessary that the immature stages of the amphibians of this habitat be brief. Prof. Thornber has mentioned the fact that the larval period of *Bufo alvarius* is short (p. 506). In the case of an unidentified species of toad found at Tucson I noted that the transition from tadpoles with a complete tail and the hind limbs but partially developed, to small toads which had acquired a terrestrial life, took place in 10 days.

Range.— *Scaphiopus couchii* has been taken in central Texas, in the Proplateau region of Arizona, and in Lower California.

Scaphiopus couchii Baird.

Habitat	Field No.	Locality	When Collected	Collector	Remarks
		Tucson, Ariz.			
Mesquite Assn.	621	Flood plain of Santa Cruz river at Tucson	Aug. 1–06	A. G. Ruthven	Adult
"	622	"	"	"	"
"	623	"	"	"	"
"	624	"	"	"	"
"	625	"	"	G. von Krockow	"
"	626	"	"	A. G. Ruthven	"
"	640	"	"	"	Eggs
	641	Deposited by toad No. 625 in captivity	"	"	"
	1046	Tucson, Arizona	Aug. 25–06	J. J. Thornber	Adult

Bufo cognatus *Say.*

Bufo cognatus "Say, Long's Exped. Rocky Mts., II, 1823, 190."— "Holbrook, North Am. Herp., V, 1842, 12."— Baird & Girard, Marcy's Explor. Red River, 1853, 213–214.— Baird, Rept. Pac. R. R. Surv., X (Whipple-Ives Route), 1859, 44.— Baird, U. S. and Mex. Bound. Surv., II, 1859, 26.— Cope, Bull. U. S. Nat. Mus., XXXIV, 1889, 275–277.— Cope, Proc. Acad. Nat. Sci. Phila., 1892, 332.— Cope, Am. Nat., XXX, 1896, 1016.— Dickerson, The Frog Book, 1906, 99–102.

Bufo lentiginosus cognatus Cope, Bull. U. S. Nat. Mus., I, 1875, 29.— Yarrow, Wheeler's Surv. West of 100th Merid., V, 1875, 521.— Yarrow, Bull. U. S. Nat. Mus., XXIV, 1883, 23, 165.

Locality.— This species is a common form about the irrigating ditches at Tucson.

Description of Specimens.— The three specimens obtained are typical of the species. The head is short, the muzzle very blunt and high, and the cranial crests diverge posteriorly from a bony protuberance situated between

the anterior part of the orbits. Back of the eyes each of these ridges is met by another which extends between the parotid gland and the eye to the tympanum. Inner and outer sole tubercles present, the outer much the larger, both with free cutting edges. The ground color in two specimens is pale yellowish gray, that of the third, dark brown anteriorly, becoming yellowish gray on the hind quarters. Muzzle variously barred with vertically elongated spots. An elongated spot over each eye. Two to four small spots between the anterior end of the parotid glands, followed by two pairs of larger and one pair of smaller, oblique spots on either side of the pale vertebral line. Limbs with similar dark spots, those on the posterior face of the leg forming two or three well defined cross bars. Under surfaces yellow, unspotted. Digits of the fore and hind limbs tipped with very dark brown.

Habitat Relations.— This toad was commonly found at dusk about the irrigating ditches, but not elsewhere.

Range.— *Bufo cognatus* is found on the Proplateau in southern Arizona and occurs on the Great Plains as far north as Nebraska, and eastward to eastern Kansas. It has also been recorded within the Rocky Mountains (Fort Garland, Colorado).

Bufo cognatus Say.

Habitat	Field No.	Locality	When Collected	Collector
Irrigating ditch, Creosote bush Assn.	604	Tucson, Arizona	July 29–06.	A. G. Ruthven
"	1047	"	Aug. 25–06	J. J. Thornber
"	1048	"	"	"

Bufo alvarius *Girard.*

Bufo alvarius Girard apud Baird, U. S. and Mex. Bound. Surv., II, 1859, 26.— Cope, Bull. U. S. Nat. Mus., XXXIV, 1889, 265–267.— Cope, Am. Nat., XXX, 1896, 1014.— Dickerson, The Frog Book, 1906, 106–108.

Locality.— One adult specimen (No. 1037) and three tadpoles of this toad, taken in Sabino Cañon, were presented to the party by Prof. Thornber.

Description of Specimen.— The adult specimen conforms closely to the descriptions given by Girard, Cope and Dickerson. The size is large (total length 147 mm.). Skin smooth, with a few, rather small, rounded warts scattered over the dorsal surface. The nostrils are large, oval and lateral. A bony crest extends backward from the nostrils and bifurcates in front of

the eye; one branch extends downward in front of the eye, the other, encircling the orbit above, reaches the ear and again divides to embrace the upper part of the typanum.

The tympanum is a large vertical oval. The parotid glands are large, oblong in form and very divergent. They begin a short distance behind the eye and extend to a point above the axillary pit. There is a single large elevated gland on the outer aspect of the thigh, a longer one (that is partially constricted into two) on the posterior face of the leg, and a long but less elevated one on the outer side of the forearm. Posterior to the angle of the mouth is a large wart preceded by two or three smaller ones.

Two large palm tubercles. Palm covered with small tubercles, a larger one at the base of the second phalange of each digit. Upper surface of fore foot covered by minute tubercles. Both inner and outer sole tubercles present, the inner much the larger.

Habitat Relations.— Professor Thornber has kindly furnished me the following account of the habits of this toad: "It is abundant in Tucson and on the University campus. One usually sees the toads a few days before the beginning of the summer showers, and their presence is taken as a sign of rain. Seldom does one see them during dry periods. They may, however, be observed about irrigation ditches and in irrigated land any time during the growing season.

"With the first heavy summer showers, as a result of which water will stand in pools, these frogs appear in abundance and lay eggs which hatch very soon; the young pass in a remarkably short time through the tadpole stage. I do not think it is more than a month's time from the egg stage to the time when the young toad hops away with his tail nearly absorbed.

"The particular specimen which I gave you was collected in Sabino Cañon, St. Catalina Mts., in June (about the 15th), 1903. A small stream of water came down from the mountains as the result of rain above, and these toads appeared in abundance pairing almost immediately. On that day every female was laying eggs. The eggs were laid in the clear stream of water, which was perhaps a foot to eighteen inches deep. I assure you there was no lack of noise that day nor night, the croaking being incessant. I have also seen it at Oracle, Ariz., where it gets into the sheep troughs and causes more or less trouble."

Range.— This seems to be the third locality recorded for this toad. The locality of the type is given as "Valley of Gila and Colorado" by Baird, and as "Fort Yuma, Calif.," by Cope. Miss Dickerson has recently recorded it from Phoenix, Arizona.

Bufo punctatus *Baird & Girard.*

Bufo punctatus Baird, Proc. Acad. Nat. Sci. Phila, 1852, 173.— Hallowell, Sitgreaves' Exped. Zuni and Colo. Riv., 1853, 143, 147.— Girard, Proc. Acad. Nat. Sci. Phila., 1854, 87.— Baird, U. S. and Mex. Bound. Surv., II, 1859, 25.— Heermann apud Hallowell, Rept. Pac. R. R. Surv., X (Williamson's Route), 1859, 25.— Cope, Proc. Acad. Nat. Sci. Phila., 1866, 313.— Cope, Bull. U. S. Nat. Mus., I, 1875, 29.— Yarrow, Wheeler's Surv. West of 100th Merid., V, 1875, 523.— Cope, Bull. U. S. Nat. Mus., XVII, 1880, 4, 29, 46, 47.— Yarrow, *ibid.*, XXIV, 1883, 22 and 162.— Cope, *ibid.*, XXXII, 1887, 10.— "Belding, West Am. Scientist, III, No. 24, 1887, 99."— Cope, Proc. U. S. Nat. Mus., XI, 1888, 395.— Cope, Bull. U. S. Nat. Mus., XXXIV, 1889, 262–264.— Stejneger, North Am. Fauna, No. 3, 1890, 117.; *ibid.*, No. 7, 1893, 219.— Van Denburgh, Proc. Cal. Acad. Sci., Ser. 2, V, 1895, 559–560.— Cope, Am. Nat., XXX, 1896, 1012.— Stone & Rehn, Proc. Acad. Nat. Sci. Phila., 1903, 34.— Dickerson, The Frog Book, 1906, 19, 110–112.

Bufo beldingii Yarrow, Proc. U. S. Nat. Mus., IV, 1882, 441.— Yarrow, Bull. U. S. Nat. Mus., XXIV, 1883, 23, 163.— "Belding, West Am. Scientist, III, No. 24, 1887, 99."

Locality.— A single specimen (No. 87) of this toad was found on the streets of Alamogordo, N. M.

Description of Specimen.— The structural characters of the single specimen obtained are entirely typical of this well defined species. The color of the dorsal surface is grayish ash with small scattered black spots, mostly grouped about the bases of the warts. Warts yellow, tipped with red. Ventral surface yellowish, the breast and submaxillary region spotted with black.

Habitat Relations.— This specimen was found after dark on the bank of an irrigation ditch. Rehn and Viereck[1] took two specimens at a spring in Dry Cañon. It is possibly a cañon form which has extended its range onto the desert floor by way of the irrigating ditches.

Range.— *Bufo punctatus* occurs in the Proplateau and Mexican Plateau regions, having been recorded from New Mexico, Arizona and northern Mexico. On the eastward it extends into central Texas, and on the westward to southern California and throughout the length of the peninsula of Lower California. So far as I know it has not thus far been taken in the Sonoran Desert.

Bufo lentiginosus woodhousii *Girard.*

Bufo dorsalis Hallowell, Proc. Acad. Nat. Sci. Phila., 1852, 181.— Hallowell, Sitgreaves' Exped. Zuñi and Colorado Rivers, 1853, 142.

Bufo woodhousii GIRARD, Proc. Acad. Nat. Sci. Phila., 1854, 86.— BAIRD, U. S. and Mex. Bound. Survey, II, 1859, 27.

Bufo frontosus COPE, Proc. Acad. Nat. Sci. Phila., 1866, 301.

Bufo lentiginosus frontosus COPE, Bull. U. S. Nat. Mus., I, 1875, 29.— YARROW, Wheeler's Surv. West of 100th Merid., V, 1875, 520.— COUES, *ibid.*, 627–628.— COPE, Proc. Acad. Nat. Sci. Phila., 1883, 14, 15.— YARROW, Bull. U. S. Nat. Mus., XXIV, 1883, 23, 165.

Bufo lentiginosus woodhousii STEJNEGER, North Amer. Fauna, No. 3, 1890, 116–117; *ibid.*, No. 7, 1893, 221.— DICKERSON, The Frog Book, 1906, 91–93.

Locality.— Twelve specimens of this toad were taken in the village of Alamogordo in July. Like its eastern representatives, *B. lentiginosus* and *americanus,* it was the common toad in the localities in which it was found.

Description of Specimens.— As has been stated by various writers it is difficult to point out characters that will distinguish the western form known as variety *woodhousii* from the eastern *B. americanus.* In general it may be said that the cranial crests are more nearly parallel in *woodhousii,* but they are little divergent in *americanus* and occasionally slightly divergent in *woodhousii,* so that this character alone cannot be relied upon. Probably the best character is the shortness of head but in the Alamogordo specimens this is not as great as given by Dickerson (one-fifth of length), but may be as low as one-fourth, a proportion often shown in *americanus.*

Colors light. Ground color grayish or yellowish brown often spotted with black. These spots may be either rather large and confluent or restricted to the bases of the warts. A whitish, grayish, or dark yellow vertebral line more or less irregular in some specimens. Ventral surface light yellow, immaculate, except for a few small black spots between the front limbs. Throat of male black.

Habitat Relations.— All of the specimens of this toad were taken in the evening along the irrigating ditches in the Mesquite association on the plains. As in the case of *B. punctatus,* the natural habitat of var. *woodhousii* is probably the cañons in the mountains, where moisture is more abundant, and it can be considered to have extended its range out onto the plain with the advent of the irrigating ditches. Nothing seems to have been recorded as to the habits of this toad. As in the case of *B. americanus* beetles make up the bulk of the food, as is shown by an examination of stomach contents. Another important article of food is the grasshopper. Doubtless spiders and caterpillars also form a part of the food as in the case of the eastern form.

During the intense heat of the day these toads were not seen, but about dusk they came out in numbers along the shallow ditches, especially near street lamps.

Range.— This is the common toad of the Great Plains and Great Basin region. It is recorded from Montana, Nebraska, Kansas, Wyoming, Colorado, Utah, New Mexico, Arizona and Texas. It is very evidently the western representative of the *B. lentiginosus* and *americanus* group, but until the relationships of these forms have been worked out, the boundary of their respective ranges cannot be established.

Bufo lentiginosus woodhousii Girard.

Habitat	Field No.	Locality	When Collected	Collector
Near irrigating ditch. Mesquite Assn.	145	Alamogordo, New Mexico	July 9–06	V. Spalding
"	249	"	July 13–06	A. G. Ruthven
"	250	"	"	"
"	251	"	"	"
"	252	"	"	"
"	253	"	"	"
"	254	"	"	"
"	255	"	"	"
"	256	"	"	"
"	257	"	"	"
"	258	"	"	"
"	286	"	July 14–06	"
"	287	"	"	"

Hyla arenicolor *Cope.*

Hyla arenicolor Cope, Jour. Acad. Nat. Sci. Phila., 1866, 84.— Cope, Proc. Acad. Nat. Sci. Phila., 1866, 301.— Cope, Bull. U. S. Nat. Mus., XVII, 1880, 47.— Boulenger, Cat. Batrach. Salient., 1882, 373.— Yarrow, Wheeler's Surv. West of 100th Merid., V, 1875, 524.— Coues, *ibid.*, 630.— Cope, Bull. U. S. Nat. Mus., XXXII, 1887, 14.— Cope, Bull. U. S. Nat. Mus., XXXIV, 1889, 369–370.— Stejneger, North Amer. Fauna, No. 3, 1890, 117–118.— Cope, Am. Nat., XXX, 1896, 1014, 1021, 1022.— Stone, Proc. Acad. Nat. Sci. Phila., 1903, 539.— Dickerson, The Frog Book, 1906, 122–123.

Hyla affinis Baird, Proc. Acad. Nat. Sci. Phila., 1854, 61.— Baird, U. S. and Mex. Bound. Surv., II, 1859, 29.

Hyla copei Boulenger, Ann. and Mag. Nat. Hist., (5), XX, 1887, 53.; *ibid.* (6), I, 1888, 189.

Locality.— Professor Thornber presented the party with two specimens of this species, which he secured in the lower part of Sabino Cañon, Santa Catalina Mountains, Ariz., May 23, 1903.

Description of Specimens.— These specimens are typical in having a rough skin, prominent disks on anterior and posterior digits, broad flat head, and no webs on the anterior digits. Hind limbs long. Eye small.

The color cannot now be determined. Several rows of dark blotches are discernible on the back, and the hind limbs are crossed by short, broad bands of darker.

Habitat Relations.— These specimens were found among the bushes on the floor of the cañon, Willow-Poplar association. No other observations have apparently been recorded on the habitat of this species.

Range.— *Hyla arenicolor* is apparently principally confined to the Mexican Plateau and Proplateau regions. Cope states that it is found as far south as Guanjuato, Mexico; the accurate northern records are White River Cañon, Tucson, Ariz., and Fort Wingate and Sante Fé, N. M. The latter records seem to indicate that it reaches the summit of the High Plateau.

Rana pipiens *Schreber.*[1]

Locality.— Taken in the lower part of Sabino Cañon and along the Santa Cruz River near Tucson.

Description of Specimens.— Size of specimens small, mostly below 45 mm. Only two obtained which reached a length of 55 mm., and none seen that were noticeably larger.

Most of the specimens in the collection are light greenish gray above, with two irregular rows of light brown spots above and about two below the dorso-lateral fold. A few are dark brown above with black spots. In the lighter individuals the limbs are light grayish ash, in the darker ones brownish ash to light brown. The markings on the hind limbs consist of cross bars on the thigh, leg and foot, and irregular markings on the posterior face of the thigh. On the fore limbs there is a short longitudinal bar on the anterior face of the forearm near the shoulder, a patch just above the point of the elbow, and three or four short cross bars on the anterior face of the forearm. Under surfaces white or yellowish white, immaculate.

Habitat Relations.— Owing to its aquatic habits it is to be expected that the habitat of this species would be very limited and sharply defined in an arid region. Specimens were only found about the margins of pools and irrigating ditches in the valley of the Santa Cruz River, and along the

[1] Miss Dickerson finds it impossible at present to recognize any subspecies in this wide-ranging and variable species. She sums up the situation as follows: "The variation of the frogs is remarkable, but no fundamental characteristic (such as proportionate length of head and body, leg measurement, etc.) remains stable when large series of frogs from adjoining districts are examined. Eastern specimens are likely to be green or brown, southern and western specimens are more often gray. Eastern frogs, especially those that frequent the salt marshes of the coast, are more smooth-skinned and slender, and on the whole more delicately moulded, while southern and western specimens are much more robust in build, have a rougher skin, and attain a large size. The material is very confusing. With a smaller series, the subspecies might have been granted. With a still more complete series, it is possible that two or three intergrading varieties of the species *pipiens* could be recognized. Much systematic study of such a series of frogs combined with knowledge of their habits and life histories, could alone produce any definite conclusion in the matter." (The Frog Book, p. 171.)

stream in Sabino Cañon. It is quite common in these habitats, but closely confined to the vicinity of the water, a fact which limits the migration routes of the species in this region to the water courses.[1]

Range.— This species, as defined at present, ranges in general from the Sierra Nevada Mountains to the Atlantic Coast.

Rana pipiens Schreber.

Habitat	Field No.	Locality	When Collected	Collector
Immediate margin of stream	678	Bed of Santa Cruz River at Tucson	Aug. 5–06	A. G. Ruthven
"	679	"	"	"
"	680	"	"	"
"	681	"	"	"
"	682	"	"	G. von Krockow
"	683	"	"	"
"	874	Bed of Santa Cruz River south of Tucson	Aug. 14–06	A. G. Ruthven
"	875	"	"	"
"	929	Creek in flood plain of Santa Cruz River south of Tucson	Aug. 16–06	"
"	930	"	"	"
"	931	"	"	"
"	932	"	"	"
"	933	"	"	"
"	934	"	"	"
"	935	"	"	"
"	936	"	"	"
"	937	"	"	"
"	938	"	"	G. von Krockow
"	939	"	"	"
"	940	"	"	"
"	941	"	"	"
"	969	In lower part of Sabino Cañon	Aug. 18–06	A. G. Ruthven
"	970	"	"	"
"	971	"	"	"
"	972	"	"	"
"	973	"	"	"
"	985	"	"	A. F. Zimmer
"	986	"	"	"
"	989	"	"	G. von Krockow
"	990	"	"	"
"	991	"	"	"
"	992	"	"	"

[1] In the timbered and prairie regions of eastern United States this frog is often found a mile or more from water, having traveled this distance through damp underbrush or long grass. Its migration routes in this region are not, therefore, confined to particular streams.

SAURIA.

Crotaphytus collaris baileyi *Stejneger.*

Crotaphytus collaris Auct. part, nec Say.

Crotaphytus collaris var. "Bocourt, Miss. Sci. Mex., Rept., 1874, 3 livr., 155."

Crotaphytus baileyi Stejneger, North Amer. Fauna, No. 3, 1890, 103–105; *ibid.*, No. 7, 1893, 165–166.— Van Denburgh, Occ. Papers, Calif. Acad. Sci., V, 1897, 53–54.— Stejneger, Proc. U. S. Nat. Mus., XXV, 1902, 149–150.

Crotaphytus collaris baileyi Stone & Rehn, Proc. Acad. Nat. Sci. Phila., 1903, 30.— Bailey, North Amer. Fauna, No. 25, 1905, 40.— Meek, Field Mus. of Nat. Hist., Zool. Ser., VII, 1905, 8.

Locality.— Eleven specimens collected near Alamogordo are referred to this variety as they all have two rows of interocular scutes.

Description of Specimens.— In seven of the twelve specimens collected the interoculars are in two distinct rows between the orbital regions; in four, however (Nos. 124, 125, 415, 416), one pair is fused into a single scute (Fig. 20). In the single specimen collected in the foothills, a very large individual (No. 295), the scales of the head are so rough that it is impossible to determine the arrangement of the interoculars with certainty, but they are apparently in two rows.

The colors of most of the specimens taken on the desert floor are strikingly pallid. The ground color above is light ash, light yellow, bluish gray, or brown relieved by numerous small, round or oblong spots of very light yellow. In some specimens these spots tend to arrange themselves in reticulations and break up the ground color into large spots. On the tail the lighter color increases to equal or exceed the darker which is broken up into a row of spots on either side of a median dorsal line. The characteristic collars consist of a pair of black bands on either side of the neck, interrupted on the throat and also on the median dorsal line. These bands are usually margined narrowly with light yellow. Belly, under surface of tail, and throat, light yellow, the anterior part of the latter occasionally marked with dark slate colored spots. In one specimen (No. 125) there is a narrow line of bright crimson before, between and behind the collars, and numerous small spots of the same color on the neck and anterior part of the body. In life there were similar neck lines on No. 109, but their color was light pink, and there were no spots on the body.

In the single specimen (No. 295) collected in the Sotol-Ocotillo association on the slopes the colors are much darker than in the desert forms. The ground color in this specimen is light olive, becoming brown toward middle of back, and on the limbs and base of tail. The light spots on the body and distal end of tail are light yellow, on the leg and proximal half of tail greenish. Fore limbs light green. Head dark brown spotted with black.

Belly and ventral surface of tail pale greenish yellow. Throat with a central, triangular patch of light blue. Sides densely and finely spotted with black.

In the younger specimens the tendency of the light dorsal spots to unite into reticulations and break up the ground color into large spots, and also to form transverse lines is more pronounced. This coloration is strikingly similar to that of the young of *C. wislizenii*, and is retained more perfectly in adults of the latter species than in *C. collaris baileyi*.

Habitat Relations.— Merriam states that in the western part of its range (southern California, Nevada and southwestern Utah) *C. collaris baileyi* is an Upper Sonoran form (Piñon-Cedar belt) and only enters the upper edge of the Lower Sonoran zone. At Alamogordo the conditions are exactly reversed, as it was found here only in the Atriplex association on the plains, and in the Sotol-Ocotillo association in the foothills of the Sacramentos. It is apparently rare in the latter habitat, while not a single specimen was taken or observed in either the Creosote bush or Mesquite associations. They doubtless occur to some extent, however, in both of the latter habitats.

In the Atriplex association, on the other hand, they are not uncommon. Here they may be seen on sunny days running about on the ground between the bushes or occasionally climbing among their branches. When approached carefully they will occasionally lie very quietly until one is within a couple of yards, their colors harmonizing so perfectly with the light soil that, unless one is aware of their exact whereabouts, it is difficult to detect them. They can seldom be approached in this way, however, as they are very shy, and usually the first intimation that one has of their proximity is a fleeting glimpse of a light colored body dashing off across the desert. When frightened they run with great swiftness from bush to bush, often for several rods, which is in contrast with the habits of the smaller lizards in the same habitat, which usually stop beneath the first clump of vegetation. They are very pugnacious, fighting furiously when wounded, but their food does not indicate as fierce a nature as that of *C. wislizenii*. As far as observed their diet consists exclusively of insects — grasshoppers, beetles and locusts being found in the stomachs of those examined. A large grasshopper forms the bulk of the contents of these stomachs.

Range.— Stejneger defines the range of *Crotaphytus collaris baileyi* as "western New Mexico, Arizona, Utah, Nevada, and northern Mexico," and that of *C. collaris* as "Kansas, Indian Territory, Arkansas, Texas and eastern New Mexico." The specimens from Alamogordo come, therefore, from a region which is supposed to be intermediate between the ranges of these two forms. We have seen, however, that specimens from Alamogordo

are undoubtedly to be referred to *C. collaris baileyi,* and as most of the Texas localities recorded for this variety are to the west of the Pecos Valley, it seems that the East Front Ranges mark approximately the eastern margin of the range of variety *baileyi.* East of this line of uplift, in the Pecos Valley, specimens showing the characters of both varieties have been recorded as well as numerous individuals in which the traits are apparently blended in various degrees. It seems, therefore, that it is in a general way in the region immediately east of the East Front Ranges in Texas that these two varieties of *Crotaphytus* grade into each other. Since in the Rio Grande Valley *C. collaris baileyi* is apparently not found on the plain but in "the lower part of the cañons and the mesas adjoining" [1] it would seem further that this variety pushes down the mountains in western New Mexico, and becomes a plains form in the Hueco bolson and Trans-Pecos region. It is thus able to intergrade with the eastern variety which is a plains form.

Range.— *C. collaris baileyi* is a typical form of the Proplateau region. It apparently does not occur as far west as Tucson in this latitude nor on the High Plateau, but follows the narrow strip of mountainous country that margins the latter region, through Arizona and southern Nevada to California.

Crotaphytus collaris baileyi Stejneger.

Habitat	Field No.	Locality	When Collected	Collector	Interocular Scutes
		Alamogordo, N.M.			
Atriplex Assn.	107	Plains between Alamogordo and White Sands	July 9–06	A. G. Ruthven	Two rows
"	108	"	July 9–06	"	"
"	109	"	"	"	"
"	124	"	"	G. von Krockow	Two rows, one pair fused
"	125	"	"	"	"
Sotol-Ocotillo Assn.	295	Foot hills of Sacramento Mts.	July 15–06	A. G. Ruthven	Two rows (apparently)
"	414	Plains west of Alamogordo	July 19–06	A. F. Zimmer	Two rows
"	415	"	"	A. G. Ruthven	Two rows, one pair fused
"	416	"	"	"	"
"	417	"	"	"	Two rows
"	448	"	"	"	"
"	507	"	July 21–06	"	"

[1] Herrick, Bull. Sci. Lab. Denison Univ., XI, 142.

Crotaphytus wislizenii *Baird & Girard.*

Crotaphytus gambelii Baird & Girard, Proc. Acad. Nat. Sci. Phila., 1852, 126.— Baird & Girard, Marcy's Explor. of Red River, 1854, 205.

Crotaphytus fasciatus Hallowell, Proc. Acad. Nat. Sci. Phila., 1852, 207–208.— Hallowell, Sitgreaves' Exped. Zuñi and Colo. Riv., 1853, 115–116, 145.— Heermann apud Hallowell, Rept. Pac. R. R. Surv., X (Williamson's Route), 1859, 24.

Leiosaurus hallowellii "Duméril, Arch. Mus., VIII, 1856, 533."

Crotaphytus copei Yarrow, Proc. U. S. Nat. Mus., V, 1882, 441.— Yarrow, Bull. U. S. Nat. Mus., XXIV, 1883, 953.

Crotaphytus wislizenii Baird & Girard, Proc. Acad. Nat. Sci. Phila., 1852, 69.— Baird & Girard, Stansbury's Exped. Great Salt Lake, 1852, 340.— Hallowell, Sitgreaves' Exped. Zuñi and Colo. Riv., 1853, 145.— Baird & Girard, Marcy's Explor. Red River, 1854, 205.— Baird, Rept. Pac. R. R. Surv., X (Beckwith-Gunnison Route), 1857, 17.— Baird, U. S. and Mex. Bound. Surv., II, 1859, 7.— Baird, Rept. Pac. R. R. Surv., X (Whipple-Ives Route), 1859, 37.— Cooper, Rept. Pac. R. R. Surv., XII, Book II, Part III, 1860, 294.— "Cooper & Suckley, Natural History of Washington Territory, 1860."— Cope, Proc. Acad. Nat. Sci. Phila., 1866, 303.— "Bocourt, Miss. Sci. Mex., Rept., 1874, 155."— Cope, Bull. U. S. Nat. Mus., I, 1875, 48.— Yarrow, Wheeler's Surv. West of 100th Merid., V, 1875, 566–567.— Coues, *ibid.*, 599.— Cope, Proc. Acad. Nat. Sci. Phila., 1883, 14, 15, 18.— Yarrow, Bull. U. S. Nat. Mus., XXIV, 1883, 9, 53.— Boulenger, Catalogue of Lizards in British Museum, II, 1885, 204.— Stejneger, North Amer. Fauna, No. 3, 1890, 105; *ibid.*, No. 7, 1893, 167–169.— Cope, Am. Nat., XXX, 1896, 1013, 1015, 1018.— Van Denburgh, Proc. Cal. Acad. Sci., Ser. 2, V, 1896, 1004; *ibid.*, Ser. 2, VI, 1896, 339.— Van Denburgh, Occ. Papers Calif. Acad. Sci., V, 1897, 56–59.— Herrick, Terry & Herrick, Bull. Sci. Lab. Denison Univ., XI, 1899, 140–141.— Cope, Rept. U. S. Nat. Mus., 1898, (1900), 255–261.— Stone & Rehn, Proc. Acad. Nat. Sci. Phila., 1903, 31.— Brown, Proc. Acad. Nat. Sci. Phila., 1903, 545, 552.— Bailey, North Amer. Fauna, No. 25, 1905, 40.— Meek, Field Mus. of Nat. Hist., Zool. Series, VII, 1906, 8–9.

Locality.— Four specimens of the Leopard Lizard were taken near Alamogordo, N. M., during July, and ten near Tucson, Ariz., in the following month. In the former locality it appears to be rare, for the four specimens secured were all that were observed. About Tucson, however, it is not an uncommon form. These notes would indicate that *C. wislizenii* is much more abundant in the western than in the eastern parts of its range, which seems to be the true state of affairs, for several writers have noted its abundance in western Arizona, Nevada, southern Utah, and eastern California,[1] while but few specimens have been recorded from eastern New Mexico and western Texas.

Description of Specimens.— In general the coloration of our specimens

[1] Baird, Rept. Pac. R. R. Surv., X (Beckwith-Gunnison Route), 17.
Yarrow, Wheeler's Surv. West of 100th Merid., V, 566.
Merriam apud. Stejneger, North Amer. Fauna, No. 7, 167–169.

of *C. wislizenii* may be described as follows: Above four longitutinal rows of dark spots (the median two the larger) on a lighter ground. These rows of spots extend from the head to the tip of the tail, and are divided into cross rows by light yellow transverse bars. On the distal end of the tail the spots fuse to form dark bands that entirely surround the tail and are separated from each other by narrow bands of light yellow. Each individual spot is surrounded by a circular mesh of very small light yellow spots that join together to form a network over the dorsal surface, the common side of the meshes that surround the two larger median rows uniting to form a single, narrow, dorsal line. The hind limbs are spotted like the body and are also crossed transversely by light yellow bands. The fore limbs have the ground color of the body and tend to have a similar coloration but the markings are usually not distinct. Belly white, usually marbled with dark slate on the sides. Throat also white, and marked with distinct longitudinal bands of dark slate.

Although the pattern is seldom as regular as this the individual variation is not as great as might be expected. The modifications are usually in the form of interruptions of the transverse bars, which generally occur between the two lateral rows of small spots on either side, and on the dorsal line between the two rows of larger spots. When the cross bands are thus interrupted the sections are usually displaced, and alternate with each other.

The differences in color due to age are much greater than the individual variations. In young specimens the coloration is of the general type described above, subject to individual modifications. The ground color of the body is grayish slate, becoming light brown toward the middle of the back and on the head. The dorsal spots are dark red, usually partly surrounded, chiefly on the posterior margin, with very dark brown. The cross bands, which are orange yellow, are broad and very distinct, and the spots that compose the finer reticulations are so close together as often to form narrow lines. The grayish color of the head is relieved by small dark brown spots, and irregular bands of yellow that tend to connect over the lips with the light spaces between the dark longitudinal bands on the anterior part of the throat.

As the individuals become older the ground color becomes light brown, the sides remaining the lighter, the individual spots of the finer reticulations become more distinct, and the light bands on the head disappear. Later the cross bands break up into small spots and lose their distinctness from the finer reticulations. In specimens of this type the large dark spots have usually increased in number (apparently by division), and have lost their serial arrangement.

In very old specimens the ground color is brownish gray, and the back

is covered with many, relatively small, dark brown spots between which are very numerous small white spots without definite arrangement. Each scale of the head has a dark brown center and is margined with white. During all of the changes in color during life the pattern on the tail is but little modified.

Habitat Relations.— Alamogordo. It is impossible to define the habitat of the Leopard Lizard at Alamogordo with certainty on account of its rareness in that locality. It was only found in the Creosote bush association on the alluvial slopes. The stomach contents of the specimens examined from this locality consist largely of insects; a large grasshopper constituting the bulk of the food.

At Tucson *C. wislizenii* is quite common although not as abundant as *Cnemidophorus melanostethus* or *Sceloporus magister*. Like these forms it occurs everywhere in the Creosote bush association on the plains, and is thus widely distributed. It is also found (although apparently in less abundance) on the flood-plain of the smaller streams (Rillito Creek and Pantano Wash) where the Mesquite, which is the dominant plant in this habitat, does not attain a great development, and the vegetation is only a little denser than that of the adjoining plain. On the flood-plain of the Santa Cruz River, it only ranges into the margin of the Mesquite association which here forms dense thickets and forests. It was nowhere found in the Suaharo-Ocotillo association on the slopes, although Merriam[1] states that it ranges to some extent upward into the Upper Sonoran zone, in southern California. The extent to which it occurs on the desert ranges in this region is as yet a question, but its principal habitat is unquestionably the Creosote bush association of the plains.

Contrary to the statements of Merriam and in accordance with the notes on the Alamogordo specimens the principal food found in the stomachs of the Leopard Lizards taken about Tucson indicate that they are chiefly carnivorous and insectivorous. A small piece of vegetable matter was found in the stomach of one young specimen, but the contents of all of the other stomachs examined consist for the most part of insects, such as grasshoppers, robber-flies and beetles. In several instances other lizards had been eaten, and the remains of *Cnemidophorus melanostethus*, *Sceloporus magister*, and young specimens of *C. wislizenii* were found in the stomachs of the larger specimens. Stejneger[2] states that he removed two full grown individuals of *Uta stansburiana* from one specimen, and a full grown horned toad and a young *C. wislizenii* from another; while Mr. Fisher[3] also discovered one in the act of swallowing a *Sceloporus*. The

[1] North Amer. Fauna, No. 7, 168.
[2] North Amer. Fauna, No. 7, 167.
[3] North Amer. Fauna, No. 7, 168.

ferocity of this lizard is indicated by the fact that adult individuals of *Cnemidophorus melanostethus* are eaten.

Range.— The distribution of *C. wislizenii* corresponds closely to that of *C. collaris baileyi,* as it is found in the Proplateau region from the East Front Ranges in Texas through southern New Mexico and Arizona to southern California (occurring to some extent on the western slope of the Sierra Nevadas),[1] and northward through southern and western Nevada to southern Oregon and Idaho.

Crotaphytus wislizenii Baird & Girard.

Habitat	Field No.	Locality	When Collected	Collector
		Alamogordo, N. M.		
Creosote bush Assn.	497	Alluvial slope east of Alamogordo	July 21–06	G. von Krockow
"	552	"	July 23–06	A. G. Ruthven
"	587	"	July 24–06	G. von Krockow
"	600	"	July 26–06	"
		Tucson, Ariz.		
"	642	Plains southeast of Tucson	Aug. 2–06	A. G. Ruthven
Suaharo-Ocotillo Assn.	676	Hill north of Rillito Creek	Aug. 4–06	"
Creosote bush Assn.	714	Plains east of Tucson	Aug. 6–06	G. von Krockow
"	747	"	Aug. 7–06	"
"	785	Plains south of Ft. Lowell	Aug. 10–06	A. G. Ruthven
"	786	"	"	"
Mesquite Assn.	792	Bank of Pantano Wash near Fort Lowell	"	"
Creosote bush Assn.	804	Plains east of Tucson	Aug. 11–06	A. F. Zimmer
"	809	"	"	G. von Krockow
Mesquite Assn.	835	Rillito Creek	Aug. 13–06	A. G. Ruthven
Creosote bush Assn.	897	Plains east of Tucson	Aug. 15–06	A. F. Zimmer
"	944	Plains south of Tucson	Aug. 17–06	G. von Krockow
Suaharo-Ocotillo Assn.	1018	Mesa west of Santa Cruz River	Aug. 21–06	A. F. Zimmer
Creosote bush Assn.	1027	Plains east of Tucson	Aug. 22–06	A. G. Ruthven

Callisaurus ventralis *Hallowell.*

Homalosaurus ventralis Hallowell, Proc. Acad. Nat. Sci. Phila., 1852, 179–180.— Hallowell, Sitgreaves' Exped. Zuñi and Colo. Riv., 1853, 117–118.— Heermann apud Hallowell, Rept. Pac. R. R. Surv., X (Williamsons Route), 1859, 24.

[1] Merriam apud Stejneger, North Amer. Fauna, No. 7, 168.

Callisaurus draconoides Lockington, Am. Nat., XIV, 1880, 295.— Boulenger, Catalogue of the Lizards in British Museum, II, 1885, 206.— Cope, Proc. U. S. Nat. Mus., XII, 1889, 147.— Townsend, *ibid.*, XIII, 1890, 144.

Callisaurus draconoides gabbi Cope, Bull. U. S. Nat. Mus., I, 1875, 47.— Yarrow, *ibid.*, XXIV, 1883, 9, 189.— Cope, Rept. U. S. Nat. Mus., 1898 (1900), 272.

Callisaurus draconoides ventralis Cope, Bull. U. S. Nat. Mus., I, 1875, 47.— Yarrow, Wheeler's Surv. West of 100th Merid., V, 1875, 565.— Coues, *ibid.*, 600.— Yarrow, Bull. U. S. Nat. Mus., XXIV, 1883, 5, 51.

Callisaurus ventralis Baird, U. S. and Mex. Bound. Surv., II, 1859, 8.— Baird, Rept. Pac. R. R. Surv., X (Beckwith-Gunnison Route), 1859, 17.— Cope, Proc. Acad. Nat. Sci. Phila., 1866, 310.— Stejneger, North Amer. Fauna, No. 7, 1893, 170–173.— Van Denburgh, Proc. Calif. Acad. Sci., Ser. 2, V, 1895, 97–99; *ibid.*, VI, 1896, 339.— Van Denburgh, Occ. Papers Calif. Acad. Sci., V, 1897, 48–51.— Meek, Field Museum of Nat. Hist., Zool. Ser., VII, 1906, 7.

Locality.— The Gridiron-tailed Lizard was found only at Tucson, and it is not surprising that a fine series of specimens was secured, as it is a common and conspicuous form in that region.

Description of Specimens.— There are some differences in color but not much variation in color pattern among the Tucson specimens of *Callisaurus ventralis*. In the darker specimens the ground color above is brownish ash relieved by small spots of light yellow or white. These light spots may be rather distinct or nearly obscured. The head is yellowish brown. There is nearly always a row of rounded dark spots on either side of the vertebral line, and often a series of indistinct, partially confluent blotches on the sides, that are quite distinct in the young. The lateral blotches are continued on the base of the tail as a dark horizontal shading, that may be broken up into spots which fuse with those of the dorsal series. The latter series are continued onto the tail, the adjacent spots of each row becoming confluent and intensified in color distally, to form about six broad, dark brown or black cross bars. The fore limbs and thighs are generally indistinctly spotted, and the legs and hind feet cross-banded, with darker. On the posterior side of the thigh there is a light yellowish line which is bordered below by a distinct dark band, and above by a narrow dark line formed by the confluence of the dusky markings on the dorsal aspect of the limb.

In the lighter colored specimens the pattern on the tail is the same as in the darker ones. The markings on the dorsal surface of the limbs may also be the same, but are frequently obscure or entirely obsolete. The ground color of the back is gray relieved by numerous minute spots of white. The head is dark yellow or light brown. In the most pallid individuals there are no dark markings above, except the usual ones on the tail, and very faint indications of dark mottlings on the limbs. The head is cream colored, the limbs white faintly tinged with yellow. The ground color of

the neck is light brownish ash in the form of reticulations enclosing areas of pure white. The ground color of the body is the same, but increased in amount, so as to constrict the lighter markings to rounded areas which are lemon yellow on the back, changing to orange yellow on the sides. On the base of the tail the cross bars are rather obscure, and separated by lemon yellow areas; distally the bars are black separated by reddish brown interspaces.

The coloration of the ventral surfaces is the same in both light and dark specimens. The inferior surface of the tail and limbs is pure white. Throat white or whitish in the females, but in males often suffused with light bluish or reddish purple, although occasionally but faintly. It is also usually crossed by several oblique, more or less distinct, lines of dusky. In nearly all females and in some males there is a gular patch of brilliant pink, and another on the lateral region of the breast. On the sides of the belly in all of the males there are two extensive patches of bright blue, broadly separated mesially by white, and containing two long triangular spots of jet black. The broadest side of these black spots lies close to the inner margin of the blue areas, and from here the blotches run forwards and upwards to the sides, the apices becoming lighter in color and blending with the dark lateral markings, when these are present. In females the blue patches are wanting, and the spots are represented by a pair of dusky markings which may be rather distinct but in most specimens are not well defined. Between the bluish patches and the hind limbs in the males, and in the corresponding region in the females the color although occasionally white is usually bright yellow, as are also the sides of the base of the tail, especially in the females. The ventral surface of the tail is white with five to eight broad, jet black markings. These markings are the continuation on the ventral surface of the cross bands of the upper surface, and each of the four or five distal ones are fused with a corresponding one on the dorsal surface to form continuous rings; there are usually one to four proximal ones, however, which do not extend to the sides of the tail but form blotches on the median ventral line. Femoral pores 13 to 24, usual number 17 or 18.

Habitat Relations.—The Gridiron-tailed Lizard is very common in the region about Tucson, but it is not, like *Cnemidophorus melanostethus*, of general distribution. It evidently prefers an open habitat, for on the mesa west of the Santa Cruz River it is found only in the ravines and on the salt spots, while on the plains east of the river it occurs in the shallow sandy washes. It is so characteristic of the ravines and washes that we could almost always depend on seeing it whenever these conditions were encountered, while we never observed it elsewhere.

Owing to their light color, individuals so closely resemble the sand that

they are rarely seen until they run. The method of running is grotesque but highly effective in covering ground. With the knees and elbows well elevated, the body about on a plane with them, and the tail curled over its back as if, says Dr. Merriam, "afraid to let it touch the hot surface of the earth," it dashes off across the sand so rapidly that it can scarcely be followed with the eye, and stops in plain view with a suddenness and apparent ease that is astonishing in view of the speed with which it is moving. When at rest its colors again blend with those of the sand, making it exceedingly difficult to discern, although one may have in view the exact spot where it stopped. In such instances, however, it often betrays itself by waving its tail above its back like a plume, which then becomes a conspicuous object owing to the contrast between the alternating black and white bands.

Merriam[1] states that "this species feeds on insects and the blossoms and leaves of plants in about equal proportions; at least such was the case in the large number whose stomachs were examined." I am unable to find any vegetable matter in the stomachs of Tucson specimens. The contents of those examined apparently consist entirely of insects — beetles, grasshoppers, robber flies, and ants (a few) being distinguishable. From the stomach of one specimen, No. 618, a mass of partially digested food was removed that may be vegetable in its nature, but it is doubtful.

Several adult females taken in August contain large eggs.

Range.— As indicated by its habits at Tucson, *C. ventralis* is an arid type, and this fact is further indicated by the nature of the region which it inhabits. Its range as defined by Stejneger[2] comprises, so far as known, "the northern portion of Lower California; the coast of Sonora, Mexico, at least as far south as Guaymas; the desert regions of southern California; southern Arizona as far east as Camp Apache and Fort Buchanan, at least; southern and western Nevada as far north as Pyramid Lake; southern Utah, where it is restricted to the Santa Clara Valley." In the central part of this region — about the lower part of the Colorado — the conditions are very arid, and the desert habitat a more open one. Here the Gridiron-tailed Lizard is probably of general distribution on the desert. To the eastward, however, the altitude increases gradually, and with this rise in elevation the vegetation also increases, and the open sandy areas become restricted to the ravines, washes and salt spots. These are the conditions that prevail about Tucson, and the fact that *C. ventralis* was only found in open habitats in this locality seems to indicate quite clearly that it is a form of the Sonoran Desert which to the eastward becomes confined to the ravines, salt spots and washes, as these alone furnish environmental conditions similar to those that prevail in the principal part of its range.

[1] North Amer. Fauna, No. 7, 172.
[2] North Amer. Fauna, No. 7, 171.

Callisaurus ventralis Hallowell.

Habitat	Field No.	Locality	When Collected	Collector	Femoral Pores
		Tucson, Ariz.			
Acacia Assn.	605	Mesa west of Santa Cruz River	July 31–06	G. von Krockow	17–18
"	606	"	"	"	
"	616	"	Aug. 1–06	A. G. Ruthven	14–17
"	617	"	"	"	17–18
"	618	"	"	"	15–15
"	619	"	"	"	18–18
"	620	"	"	"	17–18
"	627	"	"	G. von Krockow	18–19
"	628	"	"	"	18–19
"	643	Plains southeast of Tucson	Aug. 2–06	A. G. Ruthven	14–18
"	644	"	"	"	20–?
"	645	"	"	"	16–18
"	646	"	"	"	17–18
"	647	"	"	"	21–21
"	667	Mesa west of Santa Cruz River	Aug. 3–06	A. F. Zimmer	24–21
"	674	Plains north of Tucson	Aug. 4–06	G. von Krockow	16–16
"	675	"	"	"	16–15
	686	Bed of Santa Cruz River at Tuscon	Aug. 5–06	G. von Krockow	17–17
"	736	Plains east of Tucson	Aug. 7–06	A. G. Ruthven	16–18
"	737	"	"	"	17–17
"	756	Flood plains of Santa Cruz River south of Tucson	Aug. 8–06	A. F. Zimmer	17–20
"	758	"	"	G. von Krockow	18–19
Atriplex Assn.	763	Salt spot, about 4 miles north of Laboratory Hill	Aug. 9–06	A. G. Ruthven	16–16
"	764	"	"	"	17–18
"	765	"	"	"	18–18
"	766	"	"	"	13–14
"	767	"	"	"	16–18
"	768	"	"	"	19–20
Acacia Assn.	773	Mesa west of Santa Cruz River	"	"	15–16
"	774	"	"	"	18–19
"	776	"	"	"	19–21
Atriplex Assn.	781	Salt spot about 4 miles north of Laboratory Hill	"	G. von Krockow	
"	783	"	"	A. F. Zimmer	21–18
	823	Bed of Santa Cruz River	Aug. 12–06	G. von Krockow	20–22
Acacia Assn.	834	Plains north of Tucson	Aug. 13–06	A. G. Ruthven	16–17
"	843	Mesa west of Santa Cruz River	Aug. 14–06	G. von Krockow	16–16
"	844	"	"	"	18–16
"	852	"	"	A. F. Zimmer	16–19

Habitat	Field No.	Locality	When Collected	Collector	Femoral Pores
Acacia Assn.	853	Mesa west of Santa Cruz River	Aug. 14–06	A. F. Zimmer	17–18
"	854	"	"	"	16–17
"	855	"	"	"	15–16
"	857	"	"	"	18–20
"	864	"	"	A. G. Ruthven	17–?
"	865	"	"	"	18–18
"	866	"	"	"	19–19
"	867	"	"	"	18–?
"	868	"	"	"	18–17
"	873	"	"	"	17–18
"	892	Plains east of Tucson	Aug. 15–06		
"	900	"	"	G. von Krockow	18–19
"	924	Mesa west of Santa Cruz River	Aug. 16–06	A. F. Zimmer	
"	925	"	"	G. von Krockow	14–16
"	961	Plains south of Tucson	Aug. 17–06	A. G. Ruthven	16–17
"	962	"	"	"	16–17
"	963	"	"	"	24–24
"	964	"	"	A. F. Zimmer	19–20
"	965	"	"	"	17–18
Shallow wash	1003	Plains east of Tucson	Aug. 20–06	"	15–16
Ravine	1011	Mesa west of Santa Cruz River	Aug. 21–06	A. G. Ruthven	18–18
"	1012	"	"	"	18–?
"	1013	"	"	"	17–18
"	1016	"	"	A. F. Zimmer	17–17
"	1017	"	"	"	16–?

Holbrookia maculata flavilenta *Cope.*

Holbrookia propinqua Cope, Proc. Acad. Nat. Sci. Phila., 1866, 303.

Holbrookia maculata propinqua Coues, Wheeler's Surv. West of 100th Merid., V, 1875, 601.

Holbrookia maculata flavilenta Cope, Proc. Acad. Nat. Sci. Phila., 1883, 10.—Stejneger, North Amer. Fauna, No. 3, 1890, 109–110.

Locality.— Six specimens of this lizard were secured on the White Sands. It was quite abundant in this habitat, but was not found elsewhere.

Description of Specimens.— Like the other lizards taken on the White Sands, these *Holbrookias* are remarkably light colored, there being no dorsal blotches as in *H. m. approximans.* The specimens obtained are nearly pure white with two jet black, crescentric, lateral spots which are placed slightly farther forward than in *approximans*, the foremost lying under the point of the elbow in the former, generally behind it in the latter. These slight differences serve to ally the White Sands specimens with *H. m. flavilenta* and to distinguish them from *H. m. approximans.*

In one specimen (No. 113) the color of the dorsal surface is uniformly grayish white, except for faint traces of dusky on the hind limbs, sides of head, and base of tail, and numerous faint spots of orange yellow that at a distance give a slightly pinkish appearance to the body. The head is light golden yellow above. There is a faint pinkish line extending from the outer canthus along the sides of the body and base of the tail, and another from the angle of the mouth to the groin, which is continued along the inner and outer sides of the thigh and base of tail. Belly creamy white, immaculate.

Two other specimens (Nos. 473–474) are almost identical in color with the last, except that the dusky markings on the back are slightly increased in amount, making the orange spots somewhat more distinct. In No. 474 the upper surface of the head is also marked with darker.

Three others, while also very pallid, are a little darker than those described above. In the darkest individual (No. 472) the ground color is light gray, with numerous small dark spots interspersed with orange colored ones; the dark spots distinct or obscure but without definite arrangement. The amount of dark pigment is greatest on the upper surface of the limbs and tail. The color of the head is light golden yellow, that of the under surfaces the same as in the other two specimens. The pinkish lateral line is not discernible.

Scutellation apparently as in *H. m. approximans.* Tail not longer than head and body. Femoral pores 7–14.

Habitat Relations.— This *Holbrookia* was only found on the White Sands, although it probably occurs also in the Atriplex association. In this habitat it is quite common on the dunes, but very difficult to observe owing to its shyness and protective coloring. Usually the first glimpse that one gets of an individual is a flurry of sand up the side of some distant dune. When the lizard stops the orange tint of the pale ground color harmonizes so perfectly with the delicate buff or pinkish hue which the sands take on in intense sunlight, that even when looking directly at it from a distance of a few feet it is difficult to differentiate the form from the background.

It runs about on the sides of the dunes, picking up its food which consists of ants, small beetles and spiders. When surprised it dashes up the dune, taking refuge in the bushes or ground squirrel holes on the summit. Females taken in July contain large eggs.

Range.— The range of this lizard is not as yet known, as it has only been recorded from three localities. These are Lake Valley, N. M.; the Painted Desert, Ariz.; and the present locality, which is the most eastern one.

Holbrookia maculata flavilenta Cope.

Habitat	Field No.	Locality	When Collected	Collector	Femoral Pores
		Alamogordo, N. M.			
Sumac-Yucca Assn.	112	White Sands west of Alamogordo	July 9–06	A. F. Zimmer	12–12
"	113	"	"	A. G. Ruthven	7–9
"	437	"	July 19–06	"	13–14
"	472	"	"	"	8–9
"	473	"	"	G. von Krockow	9–9
"	474	"	"	"	10–11

Holbrookia maculata approximans *Baird.*

Holbrookia approximans Baird, Proc. Acad. Nat. Sci. Phila., 1858, 253–254.— "Bocourt, Miss. Sci. Mex., Rept., 1874, 163."

Holbrookia maculata approximans Cope, Bull. U. S. Nat. Mus., XXXII, 1887, 38. — Stejneger, North Amer. Fauna, No. 3, 1890, 109–110.— Van Denburgh, Proc. Calif. Acad. Sci., Ser. 2, VI, 1896, 339–340.— Van Denburgh, Occ. Papers, Calif. Acad. Sci., V, 1897, 51–53.— Cope, Rept. U. S. Nat. Mus., 1898 (1900), 297–298.— Stejneger, Proc. U. S. Nat. Mus., XXV, 1902, 150.

Locality.— Six specimens from the vicinity of Tucson, Arizona.

Description of Specimens.— These specimens differ from those of the White Sands (*H. m. flavilenta*) in having large distinct dorsal spots. These consist of two median series of distinct and paired spots, flanked on either side by a row of similar but more obscure ones. All four of these series are continued onto the base of the tail, where the two median rows fuse, and are thus represented on the distal portion of the tail by but three rows. The dorsal spots vary in the different specimens from yellow to light or dark brown. They have generally darker edges, and each is surrounded by a pale areola. The body spots have roughly the form of an ellipse broadly truncate anteriorly, and the posterior margin is nearly always crenate. The caudal spots are V-shaped proximally, but become rapidly compressed into narrow elongated bars toward the end of the tail.

Ground color above light grayish ash to dark bluish ash, with few or many small, white, or pale yellow spots. Hind feet and legs distinctly cross-banded, fore limbs and thighs less regularly so. Head above dark yellow or light brown. Belly white, unspotted. In the males there are two jet black lateral spots in a blue patch, the foremost lying behind the elbow when adpressed to the side. The throat is light bluish ash relieved by light markings on the anterior part. In the females the lateral black spots are represented by faint bluish markings, and the surrounding patch

of blue is wanting. In some specimens the throat is white, in others the posterior part is light bluish ash, the anterior part white with bluish cross bars running obliquely backward from the lips. In every female, however, there is a central patch of bright pink on the throat, that may be faint but is usually intense and well defined, and the sides of the neck, and the lateral region of the breast are also suffused with pink.

Femoral pores 12–15.

Habitat Relations.— We found this lizard in company with *Callisaurus ventralis* in the arroyos on the slopes. It resembles the Gridiron-tailed Lizard so closely in appearance and habits that it is often difficult to distinguish between these species in the field, unless one can come to close quarters.

The food in the stomachs examined consists principally of grasshoppers, although ants are present in a small amount.

Females taken during the first part of August contain large eggs.

Range.— The general range of this species is given by Stejneger[1] as "Southern Arizona, parts of Sonora, Chihuahua and Coahuila."

Holbrookia maculata approximans Baird.

Habitat	Field No.	Locality	When Collected	Collector	Femoral Pores
		Tucson, Arizona.			
Acacia Assn.	607	Mesa west of Santa Cruz River	July 31–06	G. von Krockow	12–13
"	638	"	Aug. 1–06	A. G. Ruthven	14–15
"	775	"	Aug. 9–06	"	14–14
"	777	"	"	"	15–15
"	856	"	Aug. 14–06	A. F. Zimmer	13–?
"	987[2]	Sabino Cañon, near mouth	Aug. 18–06	A. G. Ruthven	14–13

Uta stansburiana *Baird & Girard.*

Uta stansburiana Baird & Girard, Proc. Acad. Nat. Sci. Phila., 1852, 69.— Baird & Girard, Stansbury's Exped. to Gt. Salt Lake, 1853, 343–346.— Baird, Rept. Pac. R. R. Surv., X (Whipple-Ives Route), 1859, 37.— Baird, Proc. Acad. Nat. Sci, Phila., 1859, 299.— Baird, U. S. and Mex. Bound. Surv., II, 1859, 7.— Cope, Proc. Acad. Nat. Sci. Phila., 1864, 177; *ibid.*, 1866, 312.— Cope, Bull. U.

[1] North Amer. Fauna, No. 3, 109.

[2] This specimen is probably not *H. m. approximans.* It differs from the Tucson specimens of that species in having the tail flattened, the dorsal spots small and in two rows only, and the tail ringed with broad bands which are jet black below. The ground color above is light gray with numerous pale yellow spots. It is a female and lacks the blue and black spots on the sides, but has the pink throat patch and the lateral suffusion of pink. The chin is obliquely banded with light slate. It will be noted also that the habitat of this specimen is different from the other Holbrookias obtained.

S. Nat. Mus., I, 1875, 48.— Yarrow, Wheeler's Surv. West of 100th Merid., V, 1875, 568–569.— Coues, Wheeler's Surv. West of 100th Merid., V, 1875, 596–597.— Streets, Bull. U. S. Nat. Mus., VII, 1877, 37.— Lockington, Am. Nat., XIV, 1880, 295.— Cope, Proc. Acad. Nat. Sci. Phila., 1883, 12, 15, 18, 21, 28.— Yarrow, Bull. U. S. Nat. Mus., XXIV, 1883, 10, 56–57.— Boulenger, Cat. of Lizards in Brit. Museum, II, 1885, 211.— Cope, Bull. U. S. Nat. Mus., XXXII, 1887, 35.— "Belding, West Am. Sci., III, No. 24, 1887, 98."— Cope, Proc. U. S. Nat. Mus., XII, 1889, 147.— Townsend, Proc. U. S. Nat. Mus., XIII, 1890, 144.— Stejneger, North Amer. Fauna, No. 3, 1890, 106–107; *ibid.*, No. 7, 1893, 175–177.— Cope, Amer. Natur., XXX, 1896, 1013, 1015, 1018.— Van Denburgh, Proc. Calif. Acad. Sci., Ser. 2, V, 1895, 104–105; *ibid.*, 1896, 1004; *ibid.*, VI, 1896, 340.— Van Denburgh, Occ. Papers Calif. Acad. Sci., V, 1897, 66–68.— Herrick, Terry & Herrick, Bull. Sci., Lab. Denison Univ., XI, 1899, 138–139.— Cope, Rept. U. S. Nat. Mus., 1898 (1900), 306–312.— Stone & Rehn, Proc. Acad. Nat. Sci. Phila., 1903, 31.— Brown, Proc. Acad. Nat. Sci. Phila., 1903, 546, 552.— Bailey, North Amer. Fauna, No. 25, 1905, 41.— Meek, Field Museum of Nat. Hist., Zool. Series, VII, 1906, 10.

Uta elegans Yarrow, Proc. U. S. Nat. Mus., 1882, 442.— Yarrow, Bull. U. S. Nat. Mus., XXIV, 1883, 10, 55.— Boulenger, Cat. of Lizards in Brit. Museum, II, 1885, 211–212.— "Belding, West Amer. Scientist, III, No. 24, 1887, 98,"— Townsend, Proc. U. S. Nat. Mus., XIII, 1890, 144.

Uta schottii Yarrow, Bull. U. S. Nat. Mus., XXIV, 1883, 10, 55.— "Belding, West Amer. Scientist, III, No. 24, 1887, 98."

Locality.— *Uta stansburiana* is very common about Alamogordo, and a good series of specimens was secured. It is not rare at Tucson, but we did not find it nearly so abundant in that locality as at Alamogordo.

Description of Specimens.— Scutellation apparently normal. The femoral pores vary in number from 12 to 17, the normal number being apparently 14 or 15.

The ground color above is variable and may be light or dark, brown or olive brown. There is a broad light stripe that extends from the snout across the eye, and along either side of the back onto the tail, and another from the angle of the mouth to the hind limb, occasionally also indicated on the base of the tail. On the sides below the lower lateral stripe the color is bluish with numerous short vertical light lines corresponding in color to the stripes, and a prominent indigo blue spot which is broadly margined with lighter in the lateral region of the breast. The light markings just described (lateral stripes and bars) may be bright yellow, bluish white, gray or blue. The stripes are rarely complete except in front of the shoulder. Very often the lower one is represented on the body by a row of short vertical light bars situated just above the series that usually lies below the stripe. The upper stripe is nearly always complete but may be broken up into small spots. There is no definite series of markings between the stripes, but above each of the upper ones there is a single row of rather large U-

shaped spots, each one surrounded on the inner and posterior sides by a series of small, yellow, light or dark blue spots. These spots usually form a single series on the base of the tail, and are occasionally flanked by a row of smaller spots. The limbs are usually barred and spotted with the prevailing light color. In some individuals the color is dark brown, obscuring the dark spots, and the only markings consist of the stripes in front of the shoulder, the lateral spot, and very numerous small bright blue spots disposed irregularly over the dorsal surface of the neck, body, limbs and tail.

The color of the under surfaces may be white with dusky markings on the throat, or light bluish, or dark bluish slate, the throat being a darker blue with lateral markings of orange or yellow that cross the lips as vertical bars.

Habitat Relations.— Alamogordo. As illustrated by our collections, the home of *Uta stansburiana* in this region is on the desert floor. We found it to be common from the upper margin of the alluvial slope to the White Sands, but we did not find it above the alluvial slope. One specimen was taken on one of the easternmost dunes of the White Sands, but it was not observed within the Sands.

In habits this *Uta* is strictly a ground form. On the alluvial slope, where the vegetation is denser, it may be found almost anywhere on the ground, but on the desert floor, where the shrubs are much more widely scattered, it is seldom observed far from the shelter of a bush. In the Mesquite association, a favorite haunt is the small hillocks that have been built up by wind and erosion about the base of the bushes.

The food in the stomachs of the specimens examined consists of small beetles, ants, and cicadas, indicating that it is insectivorous in its food habits.

Several females taken during the latter half of July contained large eggs.

Tucson. At Tucson this lizard is distributed generally throughout the Creosote bush association on the plains. We only secured one specimen in the Suaharo-Ocotillo association on the slopes, and it probably occurs in that habitat to a more limited extent than in the Creosote bush association.

The habits of the individuals observed at Tucson are similar to those observed about Alamogordo. They were found on the ground, generally near or under a bush. These observations confirm the statement of Van Denburgh that *Uta stansburiana* is a ground-loving species.

Range.— Although Cope [1] gives the range of this species as lying "between the Rocky Mountains and the Sierra Nevada," it somewhat transcends these limits. To the east Bailey has found it in western Texas, beyond

[1] Rept. U. S. Nat. Mus., 1898, 309.

the East Front Ranges, in the Pecos Valley, while to the west it has been recorded from the west slope of the Sierra Nevadas, and in southern California reaches the coast and off shore islands, San Clemente and Santa Cruz (Townsend).[1] Apparently the most northern record is that of Summer Lake, Oregon, given by Cope[2] and Van Denburgh.[3] To the southward it is known to exist throughout the entire length of the peninsula of Lower California and on the adjacent islands (Van Denburgh),[4] but the extent of its occurrence on the mainland of Mexico is unknown.

Uta stansburiana Baird & Girard.

Habitat	Field No.	Locality	When Collected	Collector	Femoral Pores
		Alamogordo, N. M.			
Creosote bush Assn.	44	Alluvial slope east of Alamogordo	July 5–06	G. von Krockow	
"	55	"	"	"	
Atriplex Assn.	129	Plains west of Alamogordo	July 9–06	"	15–?
Creosote bush Assn.	148	Alluvial slope east of Alamogordo	July 10–06	A. F. Zimmer	
Mesquite Assn.	149	Plains near Alamogordo	"	"	
Creosote bush Assn.	292	Alluvial slope north of Alamogordo	July 15–06	A. G. Ruthven	13–13
"	293	"	"	"	15–16
Atriplex Assn.	329	Plains west of Alamogordo	July 16–06	A. F. Zimmer	15–15
Creosote bush Assn.	389	Alluvial slope east of Alamogordo	July 18–06	G. von Krockow	12–13
"	390	Alluvial slope north of Alamogordo	"	"	12–?
"	410	"	"	A. F. Zimmer	15–15
Atriplex Assn.	418	Plains west of Alamogordo	July 19–06	A. G. Ruthven	17–16
"	419	"	"	"	16–?
"	420	"	"	"	
"	426	"	"	"	15–15
"	427	"	"	"	12–14
"	435	½ mile east of White Sands	"	"	
"	436	½ mile east of White Sands	"	"	15–15
Sumac-Yucca Assn.	440	Easternmost dunes of White Sands	"	"	14–14
Atriplex Assn.	451	Three miles east of White Sands	"	"	15–15
"	457	"	"	"	15–14

[1] Proc. U. S. Nat. Mus., XIII, 144.
[2] Rept. U. S. Nat. Mus., 1898, 309.
[3] Occ. Papers Calif. Acad. Sci., V, 68.
[4] Proc. Calif. Acad. Sci., Ser. 2, V, 105, 1004.

Habitat	Field No.	Locality	When Collected	Collector	Femoral Pores
Atriplex Assn.	459	Three miles east of White Sands	July 19–06	A. G. Ruthven	15–14
"	463	"	"	"	14–14
"	465	"	"	"	15–16
"	466	"	"	"	13–14
"	478	Plains west of Alamogordo	"	G. von Krockow	
"	479	Three miles east of White Sands	"	"	14–14
"	481	"	"	"	15–15
"	484	"	"	"	12–13
"	485	"	"	"	14–14
"	490	Plains west of Alamogordo	"	"	
Mesquite Assn.	502	Plains east of Alamogordo	July 21–06	"	
"	503	"	"	A. G. Ruthven	15–16
Sotol-Ocotillo Assn.	556	Mouth of Dry Cañon	July 23–06	"	13–16
Creosote bush & Sotol-Ocotillo Assns.	559	Upper part of Alluvial slope east of Alamogordo	"	A. F. Zimmer	
Creosote bush Assns.	563	Alluvial slope north of Alamogordo	"	G. von Krockow	
"	599	"	July 26–06	A. G. Ruthven	
		Tucson, Ariz.			
Suaharo-Ocotillo Assn.	637	Mesa west of Santa Cruz River	Aug. 1–06	G. von Krockow	13–14
Creosote bush Assn.	657	Plains S. E. of Tucson	Aug. 2–06	A. G. Ruthven	
"	658	"	"	"	14–15
"	734	"	Aug. 7–06	"	
"	735	"	"	"	15–15
"	748	"	"	G. von Krockow	15–16
"	749	"	"	"	13–13
Mesquite Assn.	754	Flood-plain of Santa Cruz River	Aug. 8–06	A. G. Ruthven	
Creosote bush Assn.	805	Plains east of Tucson	Aug. 11–06	A. F. Zimmer	13–15
"	846	Mesa west of Santa Cruz River	Aug. 14–06	G. von Krockow	
"	903	Plains east of Tucson	Aug. 15–06	"	14–14
Creosote bush and Mesquite Assns.	951	Near Santa Cruz River	Aug. 17–06	G. von Krockow	14–16
"	952	"	"	"	14–14
Creosote bush Assn.	999	Plains east of Tucson	Aug. 20–06	"	16–17
"	1000	"	"	"	14–14
"	1021	Mesa west of Santa Cruz River	Aug. 22–06	A. F. Zimmer	14–14

Uta ornata *Baird & Girard.*

Uta ornata Baird & Girard, Proc. Acad. Nat. Sci. Phila., 1852, 126.— Baird, U. S. and Mex. Bound. Surv., II, 1859, 7.— Cope, Bull. U. S. Nat. Mus., I, 1875, 48.— Yarrow, Wheeler's Surv. West of 100th Merid., V, 1875, 568.— Coues, *ibid.*, 597.— Yarrow, Bull. U. S. Nat. Mus., XXIV, 1883, 56. (At least in part.)— Boulenger, Cat. of Lizards in Brit. Museum, II, 1885, 213.— Stejneger, North Amer. Fauna, No. 3, 1890, 107–108.— Cope, Am. Naturalist, XXX, 1896, 1013.— Herrick, Terry & Herrick, Bull. Sci. Lab. Denison Univ., XI, 1899, 138.— Cope, Rept. U. S. Nat. Mus., 1898 (1900), 315–317.— Bailey, North Amer. Fauna, No. 25, 1905, 41.

Uta ornata linearis Baird, U. S. and Mex. Bound. Surv., II, 1859, 7.— Van Denburgh, Proc. Calif. Acad. Sci., Ser. 2, VI, 1896, 340.

Locality.— Six specimens of *Uta ornata* were taken in the region about Tucson.

Description of Specimens.— Lateral scales small except for two rows of enlarged ones. A median dorsal band of enlarged scales, consisting of two rows of large scales, separated by smaller ones. The four rows of large scales in the dorsal series are not perfect, the larger scales in each row being occasionally separated by quite small ones.

The color of a large male is dark brown with occasional dark yellow scales. On either side of the back is a series of transverse black bars narrowly margined with yellow. These bars fuse on the tail to form dusky rings. Limbs cross-barred above. Lips and submental region dark gray grading backward through yellowish ash into a bluish green patch on the throat. Under surfaces of limbs light grayish mottled with black. Belly bright blue. Ventral surface of tail dusky gray, the dark rings faint and margined with bright blue. A preanal patch of light blue.

Females light gray above, cross bars black. Head covered above with a network of fine black lines. Below light grayish, becoming darker toward the end of the tail. Numerous short, longitudinal and undulating lines of darker on the belly. Throat patch bright orange yellow or reddish orange. Only faint indications of the dusky rings on the ventral surface of the tail. Enlarged dorsal scales often tinged with orange yellow, which in two specimens becomes a well defined patch in the sacral region.

In very young specimens (total length 45 mm.) the ground color above is light grayish. Head marked with fine black lines. Dorsal band of enlarged scales margined on either side with a narrow broken line of black, and another along the upper lateral series of enlarged scales. No lateral cross bars. Limbs cross-banded. Tail ringed with dusky. Upper lip white. Under surfaces white mottled with dark slate.

Habitat Relations.— This *Uta* was found only in the timber zone (Wil-

low-Poplar association) on the banks of the Santa Cruz River and in Sabino Cañon. In the former habitat it occurs with *Sceloporus clarkii* which it resembles in habits, being found on the trunks and limbs of the large willows and cottonwoods. In Sabino Cañon it was observed only among the large boulders that strew the bottom of the gorge.

Range.— This species has been recorded from Texas to western Arizona, but most of the localities given are so general that it is impossible to determine its range with accuracy. It probably does not occur in the desert region of southwestern Arizona, while on the plains (according to our observations) it seems to be confined to the cañons and the timber zones along the larger streams. These facts, together with the observations of Stejneger [1] that on San Francisco Mountain it occurs in the cedar zone, permits the tentative conclusion that *Uta ornata* is primarily a plateau form which is able to extend its range from the major habitat (Piñon-Cedar association) down the cañons, and into the Willow-Poplar association along the streams on the plains. Considerable light might be thrown on this point by observations of its distribution in the Piñon-Cedar association on the mountains of the Proplateau region.

Uta ornata Baird & Girard.

Habitat	Field No.	Locality	When Collected	Collector	Femoral Pores
		Tucson, Ariz.			
Willow-Poplar Assn.	752	Bank of Santa Cruz River	Aug. 8–06	A. G. Ruthven	10–11
"	841	Vicinity of Tucson	Aug. 13–06	Gift	
"	976	Lower end of Sabino Cañon	Aug. 18–06	A. G. Ruthven	11–
"	977	"	"	"	11–12
"	978	"	"	"	11–11
	1042	Tucson	Aug. 22–06	Lita Morales	

Sceloporus magister *Hallowell.*

Sceloporus magister Hallowell, Proc. Acad. Nat. Sci. Phila., 1854, 93.— Hallowell, Rept. Pac. R. R. Surv., X (Williamson's Route), 1859, 5.— Heermann apud Hallowell, *ibid.*, 24.— Stejneger, North Amer. Fauna, No. 7, 1893, 178–183.— Van Denburgh, Proc. Calif. Acad. Sci., Ser. 2, VI, 1896, 341.— Van Denburgh, Occ. Papers Calif. Acad. Sci., V, 1897, 84–86.— Herrick, Terry & Herrick, Bull. Sci. Lab. Denison Univ., XI, 1899, 125–126.— Meek, Field Mus. of Nat. Hist., Zool. Ser., VII, 1905, 10.

Sceloporus clarkii clarkii Cope, Bull. U. S. Nat. Mus., I, 1875, 40. (Part.)— Yarrow, Bull. U. S. Nat. Mus., XXIV, 1883, 11, 63. (Part.)

[1] North Amer. Fauna, No. 7, 107–108.

Sceloporus clarkii Stejneger, North Amer. Fauna, No. 3, 1890, 110–111.— Cope, Am. Nat. XXX, 1896, 1014. (Part.)— Cope, Rept. U. S. Nat. Mus., 1898 (1900), 358–363. (Part.)

Sceloporus spinosus "Günther, Biol. Centrali-Americana, 1890. (Part.)"

Sceloporus spinosus clarkii Boulenger, Cat. of Lizards in Brit. Mus., II, 1885. 227. (Part at least.)

Locality.— At Alamogordo this large scaly lizard appears to be very rare, as we obtained but four specimens. At Tucson, however, it is abundant, and thirty-seven specimens were taken.

Description of Specimens.— Dr. Stejneger has shown that the large *Scelopori* in this locality, which were formerly known as *S. clarkii*, are referable to two species, the *S. clarkii* of Baird and *S. magister* Hallowell. In the specimens obtained by the expedition the distinctive traits as pointed out by Stejneger, and the additional characters mentioned by Van Denburgh, although slight, are quite appreciable, so that it is not difficult to separate the specimens belonging to the two forms.

S. magister is the largest, although not the longest, lizard that occurs in this locality with the exception of the Gila Monster. One large specimen in our collection measures 285 mm. total length, 140 mm. body length, 125 mm. girth. About four, long, lanceolate, preauricular scales. Plates convex and head consequently rough. Top of head ovate in outline, but not as broad as in *S. clarkii*. Profile slightly arched, not decidedly flattened above as in *S. clarkii*. Femoral pores 11 to 14 (15 in one specimen).

The color is variable, and the pattern not well defined. The head above is usually mottled with dark brown and yellow or light brown. A narrow brown line extends along the infraorbital scutes from the canthus rostralis, and is continued on the neck to the shoulder. A similar line parallel to this one extends from the supralabials also to the shoulder. On the nape there are usually indications of narrow V-shaped bands. These are rarely distinct with the exception of the posterior one, which forms a narrow black collar that usually terminates on the side of the neck.

On either side of the back, about five rows of scales apart and two rows wide, are two longitudinal light bands that are usually some shade of yellow, and may be either quite distinct or obscure. On either side of each light stripe is a row of indefinite dark brown or black spots, the middle two of which may unite to form transverse bands across the back. The scales not included in the stripes or spots are usually yellow and brown, but there are often on the back and sides many blue scales, and these may be numerous enough to form blotches or a solid, broad, blue band between the stripes, and to give a bluish cast to the sides. This tendency is most conspicuous in male specimens. Again all or most of the scales on the back, sides, and neck

may be margined with orange or red, giving an orange appearance to the body. The tail is usually rather distinctly banded above with light brown, and dark brown or black. The scales on the limbs are mostly yellow with brown lateral margins which connect with those of adjacent scales, giving the appearance of narrow longitudinal stripes.

In old males the pattern above may be nearly obsolete, and the color very dark, the scales being blue black and dark brown. When the skin is being shed the color is uniformly yellowish.

The under surface in females and young specimens is usually light yellow. In the males there is generally a narrow central band of white or yellow but on either side of this are two large blotches of bright metallic blue, occasionally with interspersed scales of bright yellow. The individual scales in the blue areas are generally narrowly margined with black. Tail and ventral surface of limbs bluish white. A bright blue spot on the gular region, that may extend over the entire throat, but usually becomes lighter on the anterior part. In nearly all of the specimens the black collar is continued across the throat by black edgings to the scales.

Habitat Relations.— Alamogordo. The few specimens found at Alamogordo were all taken in the Creosote bush association on the alluvial slope. They climb about in these bushes much as they do in the large Opuntias about Tucson. In the stomach contents of these specimens, ants greatly predominate, but a few beetles are also present.

Tucson. The habitat of *S. magister* is well defined in this region. It is quite common on the Greasewood plains, but seems to be excluded from the flood-plains of the larger streams (Mesquite and Willow-Poplar associations). Mr. Jouy appears to have been the first to observe that its habitat thus differs from that of *S. clarkii.* Although it occurs in the Suaharo-Ocotillo association at the foot of the Santa Catalina and Tucson Mountains, it is much less common in these places. Its principal habitat in this region is thus preëminently the Creosote bush association of the plains.

It is very wary and rather difficult to secure as it does not run about on the desert as do the *Crotaphyti* and *Cnemidophori* but resides in the bushes. Individuals were occasionally observed in Mesquite or Creosote bushes, and more often beneath the Crucifixion thorn, but it evidently prefers the tall branching Opuntias, especially the larger ones. Here it may be seen very commonly on the trunks, upon the highest branches or in the nests of the wood rats which are constructed of the detached branches of these shrubs on the ground beneath. If the bushes are approached at a good pace the chances are that no lizards will be seen, for when frightened they scramble swiftly down the stems and into a hole, if there is time, or if not flatten themselves out against the trunk of the shrub or among the

dead branches on the ground. In such cases they do not give themselves away by the teetering movement so characteristic of many lizards, and their extraordinary resemblance to the trunk or a lobe of an Opuntia makes them very difficult to discern. Many times I have seen an individual scuttle down the trunk of one of these cacti but on carefully approaching the bush would be unable to distinguish it, although it would be in full view. Only the great development of the scales in these lizards would protect them from the needlelike spines of the Opuntias, and permit of their moving about upon them with such facility.

In regard to its food habits Dr. Merriam remarks that in the Great Basin region "*Sceloporus magister* is a mixed feeder, both insects and flowers being found in the stomachs examined. At the Great Bend of the Colorado, Nevada, and St. George, Utah, stomachs were opened that contained insects only."[1] The stomach contents of the Tucson specimens consist almost entirely of insects. A small amount of vegetable matter is present in some of them, but this is in the form of small, dried fragments that were probably taken up with the animal food. Ants make up the great bulk of the contents of these stomachs, and every one examined contained great numbers of these insects. A few beetles are also present, but they make up a very small proportion of the total contents. The stomach of one lizard that was taken under a Crucifixion thorn bush was distended with scores of winged ants.

These lizards are preyed upon by *Crotaphytus wislizenii* as shown by an examination of the stomach contents of the latter. They are doubtless also eaten by the Road Runner which is often observed in the Opuntias. The old individuals in our collection are nearly all maimed, having lost a part of their tail, a varying number of toes, or both.

Range.— Too little is known of the range and relationships of this *Sceloporus* to make it possible to determine its habitat at present. It has been recorded from southern California, Nevada, Utah, and Arizona. The Alamogordo specimens listed above thus apparently constitute the most eastern record for the species.[2] It is very probably a Proplateau form that will not be found to the eastward of the East Front Ranges in Texas, nor in the desert region of southwestern Arizona.

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[1] North Amer. Fauna, No. 7, 182.

[2] It is quite possible that the specimen of *S. clarkii* recorded by Stone (Proc. Acad. Nat. Sci. Phila., 1903, 31) from Alamogordo, may be referable to this species.

Sceloporus magister Hallowell.

Habitat	Field No.	Locality	When Collected	Collector	Femoral Pores
		Alamogordo, N. M.			
Between Creosote and Mesquite Assns.	150	Foot of alluvial slope east of Alamogordo	July 10–06	G. von Krockow	13–13
Creosote bush Assn.	182	Alluvial slope east of Alamogordo	July 12–06	A. G. Ruthven	13–14
"	495	"	July 20–06	G. von Krockow	12–13
"	496	"	"	"	13–?
		Tucson, Ariz.			
"	725	Plains east of Tucson	Aug. 7–06	A. G. Ruthven	11–11
"	726	"	"	"	12–13
"	727	"	"	"	11–12
"	728	"	"	"	12–14
"	729	"	"	"	12–13
"	745	"	"	G. von Krockow	11–11
"	746	"	"	"	
"	782	Mesa west of Santa Cruz River	Aug. 9–06	A. F. Zimmer	12–13
Creosote bush Assn.	795	Plains east of Tucson	Aug. 11–06	A. G. Ruthven	10–11
"	796	"	"	"	12–14
"	797	"	"	"	11–13
"	798	"	"	"	14–14
"	799	"	"	"	12–12
Mesquite Assn.	839	Near Rillito Creek	Aug. 13–06	G. von Krockow	12–13
"	860	Near Santa Cruz River	Aug. 14–06	A. F. Zimmer	12–13
Creosote bush Assn.	876	Plains east of Tucson	Aug. 15–06	A. G. Ruthven	12–13
"	877	"	"	"	13–13
"	878	"	"	"	12–12
"	879	"	"	"	12–12
"	880	"	"	"	12–14
"	881	"	"	"	11–12
"	882	"	"	"	14–15
"	895	"	"	A. F. Zimmer	?–14
"	896	"	"	"	12–13
"	901	"	"	G. von Krockow	11–13
"	902	"	"	"	11–13
Mesquite Assn.	943	Near Santa Cruz River	Aug. 16–06	"	13–14
"	955	"	Aug. 17–06	A. G. Ruthven	13–13
"	956	"	"	"	14–14
"	957	"	"	"	12–14
"	967	Alluvial slope of Santa Catalina Mts.	Aug. 18–06	A. G. Ruthven	12–14
Creosote bush Assn.	1001	Plains east of Tucson	Aug. 20–06	G. von Krockow	13–14
"	1005	"	"	A. G. Ruthven	
"	1006	"	"	"	11–12
"	1007	"	"	"	13–13
"	1008	"	"	"	11–11
"	1014	Mesa west of Santa Cruz River	Aug. 21–06	"	12–12

Sceloporus clarkii *Baird & Girard.*

Sceloporus clarkii Baird & Girard, Proc. Acad. Nat. Sci. Phila., 1852, 127.— Baird, U. S. and Mex. Bound. Surv., II, 1859, 5. (Part.)— Stejneger, North Amer. Fauna, No. 7, 1893, 178–183.— Cope, Amer. Natur., XXX, 1896, 1014, (Part.)— Van Denburgh, Proc. Calif. Acad. Sci., Ser. 2, VI, 1896, 340–341.— Herrick, Terry & Herrick, Bull. Sci. Lab. Denison Univ., XI, 1899, 126.— Cope, Rept. U. S. Nat. Mus., 1898 (1900), 358–363. (Part.)— Stejneger, Proc. U. S. Nat. Mus., XXV, 1902, 150.— Stone, Proc. Acad. Nat. Sci. Phila., 1903, 31 (?).— Bailey, North Amer. Fauna, No. 25, 1905, 42.

Sceloporus clarkii clarkii Cope, Bull. U. S. Nat. Mus., I, 1875, 49. (Part.)— Yarrow, Wheeler's Surv. West of 100th Merid., V, 1875, 575–576. (Part.)— Coues, *ibid.*, 594. (Part.)— Yarrow, Bull. U. S. Nat. Mus., XXIV, 1883, 11, 63, (Part.)

Sceloporus spinosus "Günther, Biol. Centrali-Americana, 1890. (Part.)"

Sceloporus spinosus clarkii Boulenger, Cat. of Lizards in Brit. Mus., II, 1885, 227. (Part ?)

Locality.— The specimens of *Sceloporus clarkii* obtained by the expedition consist of two specimens from the Santa Cruz valley south of Tucson, Arizona, and one from Sabino Cañon in the Santa Catalina Mountains. In the former locality it was not rare, and several specimens were seen during the one day spent in Sabino Cañon. It was not found at Alamogordo, although Stone and Rehn record a single specimen from that locality. As before stated (p. 535) this may be a specimen of *S. magister*.

Description of Specimens.— As shown by Stejneger and Van Denburgh, although closely similar, this *Sceloporus* is easily distinguishable from *S. magister*. The body is less stout, the head flatter above and more broadly ovate, and the snout more depressed than in *S. magister*, while the preauricular scales (about three in number) are triangular in form instead of lanceolate as in the latter species.

Femoral pores 12–13.

The coloration of *S. clarkii* is distinctive. There are no light dorsal lines, and the collar, is not, as a rule, well defined. The limbs are definitely cross-banded above (cf. *S. magister*, p. 533), even to the ends of the digits. The tail is only indistinctly cross-barred. The head is uniformly light brown, very minutely speckled with black. In females the color of the dorsal surface is light brown relieved by spots of yellow and blue, and a fairly distinct row of black cross bars on either side. In males the color is more uniform as the dark bands are wanting; the general color is dark brown with so many spots of bright blue that the entire dorsal surface has a bluish green cast.

The ventral surface of the females is light yellow often tinged with bluish on the throat, sides of belly, and tail. In the males the inferior

surface of the limbs and breast, and a narrow band along the middle of the belly, are yellow; the sides of the belly are bright blue, and there is on the throat a spot of very intense blue that fades out to a white or gray anteriorly.

Habitat Relations.— In contrast to *S. magister*, which occurs on the plains, the habitat of *S. clarkii* is limited to the timber zone along the streams (Willow-Poplar association), and in harmony with the different conditions under which it lives its habits also differ from those of the desert form. It is found only on or near trees, and when surprised does not dash down a hole as would *S. magister* under the same circumstances, but up and around the trunk, keeping on the far side of the tree like a squirrel. It is thus more arboreal in its habits than *S. magister*, a fact that determines its local distribution, for trees on the desert are confined to the larger water courses, the higher elevations on the mountains, and the bottoms of the cañons. Near Tucson *Sceloporus clarkii* occurs along the Santa Cruz River and Rillito Creek, following the tributaries of the latter into the cañons which they have carved out of the south slope of the Santa Catalina Mountains. In the lower part of Sabino Cañon I observed several individuals among the trees and bushes with *Cnemidophorus gularis*, and they seemed quite as willing when frightened to take refuge beneath the stones that strew the bottom of the gorge as to run up the trees.

The stomach contents of but one specimen was examined. It consisted entirely of insects (one caterpillar and the remains of several beetles).

Range.— Concerning the distribution of this lizard Dr. Stejneger[1] wrote in 1893 that *S. clarkii* "within the United States, seems confined to southeastern Arizona, whence it is found southward into Mexico for an unknown distance, probably confined to the western slope of the Sierra Madre, for it is pretty certain that *S. clarkii* and all its allied forms, or species, are confined to the western slope of the continent." Since that time it has been recorded from Alamogordo, N. M.,[2] and Boquillas and Langtry,[3] in western Texas.

Sceloporus clarkii Hallowell.

Habitat	Field No.	Locality	When Collected	Collector	Femoral Pores
		Tucson, Ariz.			
Willow-Poplar Assn.	684	Bank of Santa Cruz River	Aug. 5–06	A. G. Ruthven	13–13
"	751	"	Aug. 8–06	"	12–13
"	974	Lower part of Sabino Cañon	Aug. 18–06	"	12–13

[1] North Amer. Fauna, No. 7, 180.
[2] Stone and Rehn, Proc. Acad. Nat. Sci. Phila., 1902, 31 (*cf.* p. 535).
[3] Bailey, North Amer. Fauna, No. 25, 42.

Sceloporus consobrinus *Baird & Girard.*

Sceloporus consobrinus Baird & Girard, Marcy's Explor. Red River, 1853, 208–210.— Baird, U. S. and Mex. Bound. Surv., II, 1859, 5.— Baird, Rept. Pac. R. R. Surv., X (Whipple-Ives Route), 1859, 37.— Cope, Proc. Acad. Nat. Sci. Phila., 1866, 303.— Cope, Bull. U. S. Nat. Mus., I, 1875, 49.— Yarrow, Wheeler's Surv. West of 100th Merid., V, 1875, 574.— Coues, *ibid.*, 594.— Cope, Bull. U. S. Nat. Mus., XVII, 1880, 17, 44.— Cope, Proc. Acad. Nat. Sci. Phila., 1883, 15, 16.— Yarrow, Bull. U. S. Nat. Mus., XXIV, 1883, 10, 61.— Boulenger, Cat. of Lizards in Brit. Museum, II, 1885, 229–230.— Cope, Proc. Amer. Phil. Soc., XXII, 1885, 395, 397–398.— Stejneger, North Amer. Fauna, No. 3, 1890, 111.— Van Denburgh, Proc. Calif. Acad. Sci., Ser. 2, 1896, VI, 341.— Cope, Amer. Natur., XXX, 1896, 1015.— Herrick, Terry & Herrick, Bull. Sci. Lab. Denison Univ., XI, 1899, 128–129.— Stone & Rehn, Proc. Acad. Nat. Sci. Phila., 1903, 31–32.— Brown, *ibid.*, 546, 552.— Bailey, North Amer. Fauna, No. 25, 1905, 42.

Sceloporus garmani "Boulenger, Proc. Zool. Soc. Lond., 1882, 761."

Sceloporus tristichus Cope apud Yarrow, Wheeler's Surv. West of 100th Merid., V, 1875, 571–572.

Sceloporus undulatus tristichus Cope, Rept. U. S. Nat. Mus., 1898 (1900), 376–377.

Sceloporus undulatus consobrinus Cope, Rept. U. S. Nat. Mus., 1898 (1900), 377–381.— Stone, Proc. Acad. Nat. Sci. Phila., 1903, 540.

Locality. Ten specimens of *S. consobrinus* were taken near Alamogordo, where it is a common form.

Description of Specimens.— The specimens secured are approximately normal and little variable in scutellation. There is, however, some variation in size and color, which appears to be correlated with the habitat. On the basis of these characters our specimens may be divided into three groups: (1) Those taken in the Piñon-Cedar association on the mountains; (2) Those from the Creosote bush and Mesquite associations on the plains, and (3) Those from the Atriplex association and White Sands. The specimens from the desert floor (second and third groups) are all of comparatively small size,[1] and vary only in color, those from the Atriplex association and White Sands being the more pallid. Those from the Piñon-Cedar association are, however, strikingly different from the plains forms both in being more robust and in their darker color. These differences are brought out in the following descriptions.

Creosote bush and Mesquite Associations.— Head brown, spotted with black. A well defined greenish, bright or light yellow stripe extends from the outer canthus, along either side of the back and onto the base of the tail.

[1] The difference in size between the specimens from the plains and Piñon-Cedar association is not expressed so much in total length as in the proportions. In specimens of the same size from the two habitats those from the plains have a proportionately shorter body and longer tail, the tail being about 1.54–1.6 times the length of the body, as against 1.2–1.32 in those from the Piñon-Cedar association.

Above this light stripe there is a dark or reddish brown band about two rows of scales wide, which is more or less marked with black, but not in the form of definite spots. A median dorsal band of dark olive or olive brown, unspotted. Limbs above brown and spotted irregularly with black. About three rows of scales below the superior lateral stripe, there is a second or inferior light band extending from below the orbit to the hind limb. Between these light stripes is a second band of the ground color (brown or reddish brown with small irregular black spots) which also covers the upper surface of the limbs. The ventral surface of the limbs and tail are white or yellowish. The belly possesses on either side a large patch of blue (distinct in males, faint or wanting in females) separated by a wide median band of white. There is also a pair of blue spots on the throat, which are large and confluent mesially in males but small and mostly separated in females.

Atriplex and Sumac-Yucca Association.— Head light clay colored above. Median dorsal band light grayish slate. Sides of head and lateral stripes light gray or white. Stripes of ground color very light yellowish brown, reddish brown, or white, irregularly spotted with black. Under surfaces white except for the throat and belly spots. Both belly and throat spots are well defined in the males, but the former are mostly lacking in the females, the latter usually present although small.

Piñon-Cedar Association.— Head dark brown marked with black cross bars. Lateral stripes light or dark greenish yellow. Bands of ground color dark brown or olive brown crossed by numerous distinct narrow, black bars, that encroach upon and nearly interrupt the superior lateral stripe. Median dorsal band dark greenish olive. Under surface of female iridescent, throat patches small and light blue in color, throat elsewhere delicately suffused with blue. Belly white. In the male the belly is yellowish white with two lateral patches of very dark purple separated by bluish; throat patches dark metallic blue, both throat and belly patches margined with black.

Habitat Relations.— Considering the specimens obtained as belonging to a single form, the range of habitats is very large. Stone and Rehn [1] record it from Highrolls (altitude 6540), which is in the Piñon-Cedar association. We obtained it above Pinto (6000 ft.), which is also in the Piñon-Cedar association, in the Creosote bush association on the alluvial slopes, in the Mesquite and Atriplex associations on the plains and on the easternmost dunes of the White Sands. It was not found within the White Sands, not even in the bottoms, where the conditions are more like the Atriplex association than those of the surrounding dunes.

[1] Proc. Acad. Nat. Sci. Phila., 1903, 31.

It is primarily a ground form,[1] in the mountains being found among the rocks, on the plains about the foot of the bushes. On the dunes it occurs with *Holbrookia maculata flavilenta* and *Cnemidophorus sexlineatus* about the clumps of Lavender, Sumac and Yuccas.

The stomach of the only White Sand specimen examined contains a robber fly, the remains of a small beetle and a few ants A specimen taken on the plains had eaten a grasshopper, a few small beetles, ants and one or two fragments of vegetable matter.

Range.— *S. consobrinus* has been recorded in central Texas and on the Mexican Plateau, High Plateau and Proplateau. On the High Plateau Stejneger[2] states that it "is confined to the Cedar belt," and this would seem to be the case also in the Proplateau region of Arizona since we failed to find it on the alluvial slopes or plains, although it is known to occur in this general region.[3] On the other hand in eastern New Mexico and western and central Texas it occurs commonly both in the Piñon-Cedar association and on the plains. It may be found that, like *Crotaphytus collaris baileyi*, this species pushes down the mountains in the eastern part of its range.

Sceloporus consobrinus Baird & Girard.

Habitat	Field No.	Locality	When Collected	Collector	Femoral Pores
		Alamogordo, N. M.			
Piñon-Cedar Assn.	77	Box Cañon, near Pinto, N. M.	July 6–06	G. von Krockow	14–15
Atriplex Assn.	114	Plains west of Alamogordo	July 9–06	A. G. Ruthven	
"	115	"	"	"	14–15
"	128	"	"	G. von Krockow	13–14
Mesquite Assn.	158	Plains south of Alamogordo	July 11–06	A. G. Ruthven	16–16
"	159	"	"	"	14–14
Piñon-Cedar Assn.	358	Between Pinto and Highrolls, N. M.	July 17–06	"	15–15
Creosote bush Assn.	411	Alluvial slope east of Alamogordo	July 18–06	"	
Sumac-Yucca Assn.	438	White Sands west of Alamogordo	July 19–06	"	16–16
"	439	"	"	"	15–16
"	444	"	"	"	17–15
"	471	"	"	G. von Krockow	15–17
"	475	"	"	"	16–17

[1] Cope (Bull. U. S. Nat. Museum, XVII, 17) states that in central Texas "It is found on the ground, but always takes refuge in trees, running on and around the limbs with great agility." At Alamogordo we never observed it to climb about in the bushes.

[2] North Amer. Fauna, No. 3, 111.

[3] Van Denburgh, Proc. Cal. Acad. Nat. Sci., Ser. 2, VI, 341.
Cope, Rept. U. S. Nat. Museum, 1898, 380–381.

Phrynosoma hernandesi *Girard.*

Phrynosoma douglassii Cope, Proc. Acad. Nat. Sci. Phila., 1866, 302.— Allen, Proc. Bost. Soc. Nat. Hist., XVIII, 1874, 69.— Cope, Proc. Acad. Nat. Sci. Phila., 1883, 12.— Boulenger, Cat. of Lizards in Brit. Museum, II, 1885, 240–241. (Part.) — Herrick, Terry & Herrick, Bull. Sci. Lab. Denison Univ., XI, 1899, 134–135.

Tapaya douglassii Baird, Rept. Pac. R. R. Surv., X (Beckwith-Gunnison Route), 1859, 18. (Part.)

Phrynosoma douglassii douglassii Cope, Bull. U. S. Nat. Mus., I, 1875, 49. (Part.) — Yarrow, Wheeler's Surv. West of 100th Merid., V, 1875, 580–581.— Coues, *ibid.*, 591–593. (Part.)— Yarrow, Bull. U. S. Nat. Museum, XXIV, 1883, 11, 68–69.

Tapaya hernandezii "Girard, U. S. Explor. Exped., 1858, 395."— Girard apud Baird, U. S. and Mex. Bound. Surv., II, 1859, 8–9.— Baird, Rept. Pac. R. R. Surv., X (Whipple-Ives Route), 1859, 38.— "Bocourt, Miss. Sci. Mex., Rept., 1874, 228."

Phrynosoma hernandesi Cope, Bull. U. S. Nat. Mus., I, 1875, 49.— Yarrow, *ibid.*, XXIV, 1883, 11, 68. (Part.)— Stejneger, North Amer. Fauna, No. 3, 1890, 112–115.— Van Denburgh, Proc. Calif. Acad. Sci., Ser. 2, VI, 1896, 342.— Stejneger, Proc. U. S. Nat. Mus., XXV, 1902, 151.— Bailey, North Amer. Fauna, No. 25, 1905, 43.

Phrynosoma douglassii hernandesi Cope, Rept. U. S. Nat. Mus., 1898 (1900), 413–415.— Stone & Rehn, Proc. Acad. Nat. Sci. Phila., 1903, 32.

Locality. We obtained a specimen (No. 585) of this horned toad at Cloudcroft, New Mexico, where it is a common form on both slopes of the mountains. None were taken at Tucson.

Description of Specimens. One series of marginal spines. No enlarged gular scales. Horns reduced, consisting of three temporals and one occipital on either side. Occipital horns directed posteriorly but not produced as far as the adjacent temporals. Femoral pores 15–16.

In a living specimen there are four pairs of elongated rectangular black spots on the dorsal surface of the body, and a large pair of nuchal blotches. The members of each pair of spots are separated by a median dorsal band, that extends from the head to the posterior end of the triangular expansion of the base of the tail. This dorsal band is bluish white on the nape, becoming dark slate on the body, and is confluent with the spaces between the spots. The color of these interspaces varies from dark slate toward the dorsal band, to dark olive brown on the sides, thus somewhat obscuring the margins of the spots. Posteriorly the first three spots on each side are margined near the vertebral band with a narrow light yellow line. Tail, fore and hind limbs light olive, rather indistinctly barred with black above, the black bars on the tail being apparently continuations of the dorsal series that is interrupted along the vertebral line to form the dorsal spots. There

is a patch of bluish white behind the angle of the jaw, and a dark orange red line extends posteriorly from the axillary pit, just above the marginal row of spines on either side. Head dark olive brown, sides of muzzle light orange yellow. Lower lip bright red. Horns pinkish.

Ventral surface white, tinged with yellow and obscurely spotted with dark slate. Throat bright orange yellow.

Habitat Relations.— Dr. Stejneger [1] in extending the name *hernandesi* to include the Rocky Mountain horned toads previously known as *P. douglassii* or *P. douglassii douglassii* (not *Agama douglassii* Bell) gives the habitat in the San Francisco Mountain region as being "chiefly confined to the cedar belt and lower pine belt." In the Sacramento Mountains we only found it in the Pine-Spruce association on the summits, where it occurs

Fig. 20. Specimens of *Crotaphytus collaris baileyi* from Alamogordo, N. M., showing the arrangement of the interocular scales in the specimens from this region.

abundantly. We did not have the opportunity of determining the extent to which it descends the slopes, but Stone [2] states that it was "obtained abundantly by Mr. Viereck in the Transition and Canadian belts," evidently meaning by the Transition belt, the Piñon-Cedar association, although, as will be pointed out later (p. 601), the Piñon-Cedar zone is classed as Upper Sonoran by Merriam and Bailey. It is certain that it does not occur below the Piñon-Cedar association.

Range.— *Phrynosoma hernandesi* has a very extensive range, the limits of which have not as yet been definitely determined. As known at present it may be defined in general as the higher plateaus of the Rocky Mountain region in Colorado, Utah, Nevada, New Mexico and Arizona, and the mountain ranges of the Proplateau in southwestern Texas, southern New

[1] North Amer. Fauna, No. 3, 112–115.
[2] Proc. Acad. Nat. Sci. Phila., 1903, 32.

Mexico and Arizona. As it occurs in the Piñon-Cedar association its distribution along the East Front Ranges in eastern New Mexico and southwestern Texas is very probably continuous with the major part of its range to the northward. In the western part of its range the Colorado Plateau affords a continuous highway as far south as the middle of Arizona. South of the escarpment that marks the southern margin of this plateau, however, the Piñon-Cedar association only occurs on the higher isolated peaks and short ranges that rise island-like from the surrounding desert. In this region of open basins and short ranges the distribution of *Phrynosoma hernandesi* is discontinuous. It has been recorded from the Huachuca Mountains, and there is little doubt but that it occurs on most, if not all, of the ranges of this region, that rise high enough to support the Piñon-Cedar and Pine-Spruce associations.

It is not as difficult to explain the occurrence of this horned toad on the mountains of the Proplateau region in southern Arizona, as it is to account for the presence of forms of the Pine-Spruce forests on the higher summits, for it is evident that it would not have required a great decrease in temperature in this region during the glacial period to cause the Piñon-Cedar association to descend onto the higher mesas, and thus connect up isolated parts of this habitat.

Phrynosoma solare *Gray.*

Phrynosoma solare "Gray, Cat. of Lizards in Brit. Museum, 1845, 229."— Van Denburgh, Proc. Calif. Acad. Sci., Ser. 2, IV, 1894, 456; *ibid.*, V, Ser. 2, 1895, 115.— Cope, Amer. Natur., XXX, 1896, 1014.— Van Denburgh, Proc. Calif. Acad. Sci., Ser. 2, VI, 1896, 342.— Cope, Rept. U. S. Nat. Mus., 1898 (1900), 420–423.

Phrynosoma regale "Girard, U. S. Explor. Exped., 1858, 406."— Girard apud Baird, U. S. and Mex. Bound. Surv., II, 1859, 9.— Cope, Proc. Acad. Nat. Sci. Phila., 1866, 302.— "Bocourt, Miss. Sci. Mex., Rept., 1874, 235."— Yarrow, Wheeler's Surv. West of 100th Merid., V, 1875, 578.— Coues, *ibid.*, 593.— Cope, Bull. U. S. Nat. Mus., I, 1875, 49.— Lockington, Am. Natur., XIV, 1880, 295.— Yarrow, Bull. U. S. Nat. Mus., XXIV, 1883, 11, 66 — Boulenger, Cat. of Lizards in Brit. Museum, II, 1885, 245.

Locality.— A single specimen of *Phrynosoma solare* was taken about a quarter of a mile south of old Fort Lowell, Arizona. Prof. Thornber also presented the expedition with five specimens taken in the vicinity of Tucson.

Description of Specimens. (Fig. 21.)— This is one of the most spinous species of the genus, as one usually becomes aware when he endeavors to capture one alive. The horns are large, flattened in the dorso-ventral plane, slightly upcurved, and consist of four occipitals and six temporals, three on either side. The temporals are on a slightly lower plane than the occipitals,

but the difference in elevation is so slight that the appearance is that of a continuous ruff of horns about the back of the head. There are two rows of marginal spines, the inferior consisting of small acuminate scales, the superior of elongated, pyramidal spikes set very closely together. The two rows are separated by several series of small flat scales.

On either side of the dorsal line are one or two series of rather large, keeled and slightly elevated scales, and lateral to these four spaced rows of much larger, strongly keeled, mucronate and elevated ones. The spines of the two upper rows on either side are the larger, much broader than wide, their posterior faces are convex and their anterior concave. The spines of

Fig. 21. *Phrynosoma solare* from Tucson, Ariz.

the two lower rows are more erect and narrower, and of a pyramidal form. Posteriorly the first and third rows end in the lumbar region, the third in the lateral abdominal region, the second on the triangular base of the tail, but the spines of the fourth row, becoming more erect, continue nearly to the end of the tail. Below this series on the tail is a row of slender pyramidal spines that seems to be a continuation of the upper marginal row on the body, although the connection between the two series is not definite. Ventral to this marginal series of spines on the tail there is a short row of points on the expanded base.

The forelimb and leg are covered above with large, keeled and mucronate

scales. On the thigh there are small, keeled scales interspersed with large scattered spines, and a row of keeled and pointed scales on the inner margin.

The general color is pale. There is a vertebral line of light yellow extending from the head to the end of the expanded base of the tail, and a similar narrower line on either side between the second and third rows of enlarged scales, extending from the neck to the lumbar region. The nuchal blotches are very dark brown. The ground color on the sides is bright yellow, somewhat variegated with dark brown which replaces the yellow near the light longitudinal line, and connects along these lines with the nuchal spots. The flattened scales adjacent to the light vertebral band and the fourth row of spines are also brown, and have black keels. The small scales between the flattened vertebral scales, the lateral light lines, and the third row of large spines are very light yellow. The hind limbs are barred with very dark brown above, but not very definitely. On either side of the expanded base of the tail is a large black blotch separated from its neighbor by the light vertebral line. This line is absent on the distal part of the tail, however, and the pattern consists of alternate bars of bright yellow and black. The head is light gray, becoming dark brown toward the tip of the occipital horns.

Habitat Relations.— Apparently nothing has been recorded on the habits of *Phrynosoma solare.* The single specimen taken was found beneath a Creosote bush on the plains just south of old Fort Lowell (Creosote bush association). Without doubt the five specimens taken by Mr. Price [1] "on the desert near Fort Lowell" were from this habitat, and probably also the specimens in the National Museum (Nos. 8437 and 17179) recorded by Cope.[2]

The stomachs of the two specimens examined were both gorged with the remains of scores of ants.

Range.— Unfortunately but few specimens of this horned toad have been recorded, so that it is impossible, as yet, to accurately define its range. Most of the literature that has accumulated has been based on specimens from the following localities: "California"; "Gila and Colorado Desert"; Fort Lowell and Tucson, Arizona; Hermosilla, Mexico; Las Animas Bay, Lower California. Few as these records are they indicate that the home of *P. solare* is the same as that of *Callisaurus ventralis* — the Sonoran Desert in the extreme southwestern United States, and western Mexico — and like the latter species it probably pushes little farther into the Proplateau region than Tucson, Arizona.

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[1] Proc. Calif. Acad. Sci., Ser. 2, VI, 342.
[2] Rept. U. S. Nat. Mus., 1898, 423.

Phrynosoma solare Gray.

Habitat	Field No.	Locality	When Collected	Collector
		Tucson, Ariz.		
Creosote bush Assn.	793	Plains south of Fort Lowell	Aug. 10–06	A. G. Ruthven
	1094	Tucson, Arizona	?	J. J. Thornber
	1095	"	?	"
	1096	"	?	"
	1097	"	?	"
	1098	"	?	"

Phrynosoma cornutum *Harlan.*

Agama cornuta Harlan, Jour. Acad. Nat. Sci. Phila., IV, 1825, 299; *ibid.*, VI, 1829, 14.— "Griffith, Cuvier's Anim. King., IX, 1831, 216."— Harlan, Med. and Phys. Res., 1835, 141.

Tapaya cornuta "Cuvier, Règ. Anim., II, 1829, 37."

Phrynosoma bufonium "Wiegmann, Isis, 1828, 367."— "Gray, Syn. Rept. Griff. Cuvier's Anim. King., IX, 1831, 45."

Tropidogaster cornutus "Fitzinger, System. Rept., I, 1843, 79."

Tropidogaster bufonium "Fitzinger, System. Rept. I, 1843, 79."

Phrynosoma harlanii "Wiegmann, Herpt. Mex., I, 1834, 54."— Duméril & Bibron, Erpétologie Générale, IV, 1837, 314–318.— "Spring & Lacordiere, Anat., Pt. 2, 192, Bull. Acad. Roy. Bruxelles, 1842."— "Duméril, Cat. Meth. Coll. Rept. Mus., 1851, 28."

Phrynosoma orbiculare "Holbrook, North Amer. Herp., II, 1842, 93."

Phrynosoma planiceps Hallowell, Proc. Acad. Nat. Sci. Phila., 1852, 178.— Hallowell, Sitgreaves' Exped. Zuñi and Colo. Riv., 1853, 124–125.— Cope, Bull. U. S. Nat. Mus., I, 1875, 49.— Coues, Wheeler's Surv. West of 100th Merid., V, 1875, 593.— Yarrow, *ibid.*, 579.

Phrynosoma cornutum planiceps Boulenger, Cat. of Lizards in Brit. Museum, II, 1885, 246.

Phrynosoma cornutum "Gray, Syn. Rept. Griff. Cuvier's Anim. King., IX, 1831, 45."— "Holbrook, North American Herpetology, II, 1842, 87."— "Gray, Cat. Liz. Brit. Mus., 1845, 229."— Girard, Stansbury's Exped. Gt. Salt Lake, 1852, 360.— "Blanchard, Organ. Reg. Anim., 1852, Pt. 5."— Hallowell, Sitgreaves' Exped. Zuñi and Colo. Rivers, 1853, 119–122, 145.— Baird & Girard, Marcy's Explor. of the Red Riv., 1854, 204–205.— "Girard, U. S. Explor. Exped., 1858, 403."— Baird, U. S. and Mex. Bound. Surv., II, 1859, 9.— Baird, Rept. Pac. R. R. Surv., X (Whipple-Ives Route), 1859, 37.—"Bocourt, Miss. Sci. Mex., Rept., 1874, 236."— Cope, Bull. U. S. Nat. Mus., I, 1875, 49.— Yarrow, Wheeler's Surv. West of 100th Merid., V, 1875, 579.— Cope, Bull. U. S. Nat. Mus., XVII, 1880, 17–18, 44, 46.— Yarrow, *ibid.*, XXIV, 1882, 11, 66–67.— Cope, Proc. Acad. Nat. Sci. Phila., 1883, 10, 12.— Boulenger, Cat. of Lizards in Brit. Museum, II, 1885, 245–246.— Cope, Proc. Am. Phil. Soc., XXII, 1885, 169; *ibid.*, XXIII, 1886, 282. — Cope, Bull. U. S. Nat. Mus., XXXII, 1887, 39.— Cope, Proc. U. S. Nat. Mus.,

XI, 1888, 398.— Cope, Proc. Acad. Nat. Sci. Phila., 1892, 335.— Van Denburgh, Proc. Calif. Acad. Sci., Ser. 2, VI, 1896, 342.— Herrick, Terry, & Herrick, Bull. Sci. Lab. Denison Univ., XI, 1899, 135–136.— Cope, Rept. U. S. Nat. Mus., 1898 (1900), 432–436.— Cope, Proc. U. S. Nat. Mus., XXV, 1902, 151.— Stone & Rehn, Proc. Acad. Nat. Sci. Phila., 1903, 32.— Stone, *ibid.*, 540.— Brown, *ibid.*, 546, 552. — Bailey, North Amer. Fauna, No. 25, 1905, 43.

Locality.— Phrynosoma cornutum is the common horned toad on the desert about Alamogordo, N. M., where nine specimens were taken. It has been recorded from southeastern Arizona, and even from the vicinity of Fort Lowell,[1] but we did not find it in this region.

Fig. 22. *Phrynosoma cornutum* from Alamogordo, N. M.

Description of Specimens. (Fig. 22.) — The ground color above varies from dark orange yellow to dark brown. There is a pale vertebral line, and two rows of large, dark brown or black spots on either side. There are four spots in the lower series, three or four in the upper row, and the last spot in each series is usually united with the corresponding spot in the adjacent row to form a deeply notched cross band. There is also a similar pair of large spots on the base of the tail, separated by the vertebral line that extends to the slender portion of the tail. All of these spots are gener-

[1] Cope, Rept. U. S. Nat. Mus., 1898, 436.

ally margined broadly with bright yellow. Distal end of tail cross-barred with black or dark brown; upper surface of limbs irregularly barred with the same color.

Head and face distinctly barred with black. The pattern on the head usually consists of a transverse bar between the superciliary horns, and similar bars across the middle and anterior portions of the interorbital region. On the sides of the head a dark bar extends from the anterior bar on the top of the head across the mouth, another also across the mouth from the middle of the orbit, a third extends from the posterior orbital angle to the first temporal horn, and a fourth from the superciliary horns to a point between the occipital and third temporals. The occipitals, first and usually a varying amount of the second temporals, and the posterior halves of the superciliary horns are very dark horn color, the third and part of the second temporal spines light horn color. Ventral surfaces very light yellow or cream colored, with scattered dusky spots.

Habitat Relations.— Like *Anota modesta* the habitat of *P. cornutum* is the plains. It is the common horned lizard of the Mesquite association about Alamogordo, and in the Creosote bush association of the adjacent alluvial slopes. It was not found in the Atriplex association west of Alamogordo, nor on the Sacramento Mountains.

Almost nothing has been recorded on the habitat of this reptile. Rehn and Viereck only record it from the plain about Alamogordo. Herrick states that it is common in the valley of the Rio Grande, and Bailey that it is an arid Lower Sonoran form in Texas.

An examination of several stomachs shows that the principal food is insects; ants greatly predominating. Beetles are present in small numbers, and a few leaves of some weed, which may have been taken in accidentally with the food. Cope[1] records specimens from Lake Valley, N. M., as "full of eggs in June."

Range.— *P. cornutum* occurs chiefly in the Proplateau region of western Texas, southern New Mexico, and southeastern Arizona, and on the northern part of the Mexican Plateau. It has been recorded from Utah.[2] To the eastward it extends through central Texas into the margin of the forest area of the eastern part of the State.

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[1] Proc. Acad. Nat. Sci. Phila., 1883, 10.
[2] Rept. U. S. Nat. Mus., 1898, 436.

Phrynosoma cornutum Harlan.

Habitat	Field No.	Locality	When Collected	Collector
		Alamogordo, N. M.		
Mesquite Assn.	84	Plain near Alamogordo	July 7–06	G. von Krockow
"	86	"	"	A. F. Zimmer
"	110	"	July 9–06	A. G. Ruthven
"	146	"	July 10–06	"
"	151	"	"	G. von Krockow
Creosote bush Assn.	413	Alluvial slope east of Alamogordo	July 18–06	A. G. Ruthven
"	590	"	July 25–06	G. von Krockow
Mesquite Assn.	603	Plain near Alamogordo	July 26–06	A. G. Ruthven

Anota modesta *Girard.*

Phrynosoma modestum Girard, Stansbury's Exped. Gt. Salt Lake, 1852, 365.— Hallowell, Sitgreaves' Exped. Zuñi and Colo. Rivers, 1853, 145.— Cope, Proc. Acad. Nat. Sci. Phila., 1866, 302.— "Bocourt, Miss. Sci. Mex., Rept., 1874, 232." — Yarrow, Wheeler's Surv. West of 100th Merid., V, 1875, 577.— Coues, *ibid.*, 594.— Cope, Bull. U. S. Nat. Mus., I, 1875, 49.— Cope, Proc. Acad. Nat. Sci. Phila., 1883, 10, 12.— Yarrow, Bull. U. S. Nat. Mus., XXIV, 1883, 11, 64.— Boulenger, Cat. of Lizards in Brit. Museum, II, 1885, 248.— Cope, Proc. Am. Phil. Soc., XXIII, 1886, 282.— Cope, Bull. U. S. Nat. Mus., XXXII, 1887, 38.— Cope, Proc. Acad. Nat. Sci. Phila., 1892, 335.— Van Denburgh, Proc. Calif. Acad. Sci., Ser. 2, VI, 1896, 342.— Brown, Proc. Acad. Nat. Sci. Phila., 1903, 546, 552.— Bailey, North Amer. Fauna, No. 25, 1905, 43–44.

Doliosaurus modestus "Girard, U. S. Explor. Exped., 1858, 309."— Baird, U. S. and Mex. Bound. Surv., II, 1859, 10.— Girard, Rept. Pac. R. R. Surv., X (Whipple-Ives Route), 1859, 38.

Phrynosoma platyrhynus Herrick, Terry & Herrick, Bull. Sci. Lab. Denison Univ., XI, 1899, 136–137.

Anota modesta Cope, Amer. Natur., XXX, 1896, 1014.— Cope, Rept. U. S. Nat. Mus., 1898 (1900), 437–439.— Stone & Rehn, Proc. Acad. Nat. Sci. Phila., 1903, 32.

Locality.— Seven specimens of *Anota modesta* were secured on the plains about Alamogordo, where it is quite common but not as abundant as *P. cornutum.* It was not found about Tucson, Arizona.

Description of Specimens.— There is little variation in the coloration of the specimens taken in the Atriplex association. The ground color above is light brownish yellow. The only markings on the head consist of numerous small black spots that are usually, but not always, confined to the points of the rugosities. On the nape there is a pair of large nuchal blotches that extend from the head to a point behind the fore limbs, and a similar

pair in front of the hind limbs. These spots may or may not connect along the sides of the body. On the dorsal surface there are usually numerous small, black or dark brown spots that may occur singly or grouped into larger spots. The limbs are usually indistinctly and irregularly barred above, and there is a series of distinct cross bars on the tail. The proximal band is usually divided on the median line, and the two halves expand to form a large spot on either side of the triangular base of the tail.

In one specimen taken in the Creosote bush association the ground color above is light orange yellow, the head being dark slate. There are no spots on the dorsal surface, the usual large spots on the sides being represented by a dusky shade that extends along either side from the head to the hind limb.

In the other specimen taken in the Creosote bush association the ground color is yellowish gray; that of the head light slate. No dorsal spots, and the usual lateral spots represented only by a dark shading.

The ability that some horned toads have of changing their color has often been remarked upon. That this species has this power was shown in a striking way by specimen No. 122. It was necessary to shoot this specimen, as it was making for an impenetrable Crucifixion thorn bush when discovered. It was not seriously injured, but bled quite freely, and when the bag in which it was placed became stained with the blood, the large black lateral spots, which were previously very distinct, became a bright pink, and remained so for four hours, only becoming black again when the specimen was killed.

Habitat Relations.— This horned toad was found about Alamogordo only on the plains and the adjacent alluvial slope. It is widely distributed there, however, occurring in the Atriplex, Mesquite and Creosote bush associations, being apparently more common in the Atriplex association west of Alamogordo.

Bailey[1] states that "apparently the species belongs to Lower Sonoran zone and extends to its extreme upper limit." According to his interpretation this would mean that *A. modesta* occurs through the Sotol-Ocotillo association to the lower limit of the Piñon-Cedar zone. This it does not seem to do in this part of its range, as no specimens were observed by us above the Creosote bush association on the alluvial slope, and Rehn and Viereck only record it from "the plains about Alamogordo." It is entirely probable, however, that it occurs to some extent in the Sotol-Ocotillo association as there is no sharp line between this zone and the adjacent Creosote bush association, but be this as it may it is quite evident that the principal home of *Anota modesta* in this region is on the plains.

[1] North Amer. Fauna, No. 25, 43.

The stomach contents of several specimens consist very largely of ants; a few beetles are also present, and a small amount of vegetable matter.

Range.— The limits of the range of *Anota modesta* are not as yet definitely known, but as far as our knowledge goes its distribution is in harmony with the arid character of its habitat.

It occurs in the Prairie region of central Texas between the 98th meridian and the eastern edge of the Staked Plains. To the south it skirts the margin of the High Plateau, and is found in the open arid basins of the Mexican Plateau and Proplateau regions as far westward as southeastern Arizona. In western Texas and New Mexico it takes advantage of the three highways that permit the most northern extension of the range of the plains types in this region, and is found in the Pecos, Hueco, and Rio Grande basins, in the latter possibly as far north as Albuquerque. The western boundary of its range in southern Arizona seems to be marked in general by the western margin of the Proplateau, but it may be found to follow this feature through the central part of the State.

Anota modesta Girard.

Habitat	Field No.	Locality	When Collected	Collector	Femoral Pores
		Alamogordo, N. M.			
Atriplex Assn.	111	Plains west of Alamogordo	July 9–06	A. G. Ruthven	13–13
"	122	"	"	G. von Krockow	15–15
Creosote bush Assn.	219	Alluvial slope east of Alamogordo	July 13–06	A. G. Ruthven	10–9
"	412	"	July 18–06	A. G. Ruthven	12–12
Atriplex Assn.	467	Plains west of Alamogordo	July 19–06	A. F. Zimmer	14–10
"	468	"	"	A. G. Ruthven	12–12
"	469	"	"	A. F. Zimmer	11–12

Coleonyx brevis *Stejneger.*

Stenodactylus variegatus Baird, U. S. and Mex. Bound. Surv., II, 1859, 12. (Part.)

Eublepharis variegatus Boulenger, Cat. of Lizards in Brit. Museum, I, 1885, 233–234.— Cope, Amer. Natur., XXX, 1896, 1009.— Cope, Rept. U. S. Nat. Mus., 1898 (1900), 466–469. (Part.)

Coleonyx variegatus Cope, Bull. U. S. Nat. Mus., I 1875, 52. (Part.) — *Ibid.*, XVII, 1880, 13–14, 44, 46.— Yarrow, *ibid.*, XXIV, 1883, 11, 72. (Part.).— Herrick, Terry & Herrick, Bull. Sci. Lab. Denison Univ., XI, 1899, 119.

Coleonyx brevis Stejneger, North Amer. Fauna, No. 7, 1893, 162–164.— Bailey, *ibid.*, No. 25, 1905, 44.

Locality.— A single specimen (No. 55) of this Gecko was taken near Alamogordo, New Mexico. The Geckos obtained at Tucson belong to the following species.

Description of Specimens.— Pupil vertical, eyelids well developed. Head and body above covered with small granular scales except about the mouth and nostrils. Tail cylindrical, covered with whorls of small scales. A small spine on either side of the base of the tail. Toes conical, covered with small scales, and possessing a median ventral series of wide lamellæ; claws short. Seven small supralabial plates extending from a well developed rostral to a point beneath the eye. A similar row of infralabials diverging from a large symphysial plate. A single prenasal scute applied to the sides of the rostral, and separated from its neighbor on the opposite side by a small scale behind the apex of the rostral.

The differences between *C. brevis* and *C. variegatus* are so slight that it is impossible on the basis of most of them to determine the species of the few specimens obtained by the expedition. Thus both in the individuals from Alamogordo and from Tucson the snout is a trifle longer than the distance from the posterior angle of the orbit to the ear, and the number of superior labials in the Alamogordo specimen is the same as in one from Tucson. The size of the internasals, however, separates sharply the Alamogordo specimen from those from Arizona. In the former specimen, as stated above, the prenasal scutes are separated from each other on the median line, while in both of the individuals from Tucson they are broadly in contact. Whether or not the differences between eastern and western individuals are of specific value, however, is another question. It seems quite probable that the two forms may subsequently be found to intergrade.

Habitat Relations.— This Gecko is evidently nocturnal in its habits as is evidenced by its vertical pupil. Cope [1] states that he found it in western Texas "in the rocky hills of the first plateau northwest of San Antonio." The Alamogordo specimen was taken under a large stone, in the upper part of the Creosote bush association on the talus slope. It doubtless does not occur commonly on the plains owing to the absence of rocks and other objects under which it could hide, but it may be expected to occur in the Sotol-Ocotillo zone of the foot hills. (Compare habitat relations of *C. variegatus*, p. 554.)

Range.— Before the species *C. brevis* was established, the range of *C. variegatus* was given as central Texas to California. Since the eastern and western forms were separated, however, there has been a questionable region between Tucson, Arizona, the most eastern record for *C. variegatus*,

[1] Bull. U. S. Nat. Mus., XVII, 14.

and central Texas, the only region from which specimens of *C. brevis* have been recorded. The Alamogordo specimen helps very materially to bridge this gap by carrying the range of *C. brevis* well into the Proplateau region. The western limit of its range must now be sought to the westward of the Hueco bolson.

Coleonyx variegatus *Baird.*

Stenodactylus variegatus Baird, Proc. Acad. Nat. Sci. Phila., 1858, 254.— Baird, U. S. and Mex. Bound. Surv., II, 1859, 12. (Part.)

Eublepharis fasciatus Boulenger, Cat. of Lizards in Brit. Museum, I, 1885, 234.

Coleonyx variegatus Cope, Proc. Acad. Nat. Sci. Phila., 1866, 310; *ibid.*, 1867, 85.— Cope, Bull. U. S. Nat. Mus., I, 1875, 50. (Part).— Coues, Wheeler's Surv. West of 100th Merid., V, 1875, 590.— Yarrow, Bull. U. S. Nat. Museum, XXIV, 1883, 11, 72. (Part.)— Stejneger, North Amer. Fauna, No. 7, 1893, 162–164.— Van Denburgh, Occ. Papers Calif. Acad. Sci., V, 1897, 40–42.— Cope, Rept. U. S. Nat. Museum, 1898 (1900), 466–469.— Meek, Field Museum of Nat. Hist., Zool. Series, VII, 1905, 4.

Locality.— Two specimens (Nos. 840 and 1035) of *Coleonyx variegatus*, which had been taken near Tucson, were presented to the party, one by Prof. Thornber.

Description of Specimens.— Similar to *C. brevis*, but with better developed prenasal scutes which meet broadly above. Superior labials 7 in one specimen and 6 in another. Both specimens secured were in alcohol so that the colors of the living animal could not be obtained. The general color pattern is as follows: A broad, transverse, dark band on the neck and four on the body. These bands are continued onto the tail, forming rings on the distal portion. Between these bands the color is white, with a few dark spots, especially on the sides. Ground color of head white with numerous, rather large, dark spots that tend to become elongated longitudinally on the snout.

Habitat Relations.— This form, like its more eastern relative *C. brevis*, is also nocturnal in its habits. Van Denburgh[1] remarks that "An individual kept in confinement for more than a year spent most of his time in a hole provided in the ground of his cage. His food during this time consisted entirely of house flies. His usual time of feeding was after dark, but not infrequently he would snap up a fly which chanced to stray into the mouth of his burrow during the day, and sometimes would come forth in search of prey while the sun was shining brightly on his den."

Prof. Thornber's specimen (No. 1035) was found under a board on the University grounds, which are in the Creosote bush association, where he

[1] Occ. Papers, Calif. Acad. Sci., V, 42.

says it is occasionally captured under boards or piles of cord wood. The habitat of the other specimen was unknown. Prof. F. E. Lloyd informed us that he had observed it quite frequently under stones on Laboratory Hill. The latter habitat is undoubtedly a natural one, and it is doubtless to be found in the Suaharo-Ocotillo association on most of the higher elevations in this region. We do not believe that it will be found to occur commonly in the Creosote bush association on the plains, owing to the absence of objects under which it may hide, although it may occur here in holes instead of under stones as on the higher elevations.

Range.— In the discussion of the range of *C. brevis* it was stated that the known eastern limit of *C. variegatus* is Tucson, Arizona. It is known to extend from here westward to the Sierra Nevadas in southern California (Inyo, Kern and Riverside counties). Its northern and southern distribution is still unknown, but it has been recorded from Ventanas, Mexico, and San Filipe, Lower California.

Heloderma suspectum *Cope.*

Heloderma horridum Baird, U. S. and Mex. Bound. Surv., II, 1859, 11.— Baird, Rept. Pac. R. R. Surv., X (Whipple-Ives Route), 1859, 38.— Cope, Proc. Acad. Nat. Sci. Phila., 1866, 303.

Heloderma suspectum Cope, Proc. Acad. Nat. Sci. Phila., 1869, 5.— Cope, Bull. U. S. Nat. Mus., I, 1875, 47.— Yarrow, Wheeler's Surv. West of 100th Merid., V, 1875, 562–563.— Coues, *ibid.*, 601–602.— "Bocourt, Miss. Sci. Mex., Rept., 1878, 297."—"Yarrow, Bull. U. S. Nat. Mus., XXIV, 1883, 9, 48.— Boulenger, Catalogue of Lizards in Brit. Museum, II, 1885, 302.— Stejneger, North Amer. Fauna, No. 7, 1893, 194–195.— Cope, Amer. Natur., XXX, 1896, 1014.— Van Denburgh, Occ. Papers Calif. Acad. Sci., V, 1897, 120–122.— Herrick, Terry & Herrick, Bull. Sci. Lab. Denison Univ., XI, 1899, 144.— Cope, Rept. U. S. Nat. Mus., 1898 (1900), 476–483.— Brown, Proc. Acad. Nat. Sci. Phila., 1903, 552.

Locality.— One specimen (No. 968) of the Gila Monster was brought back by the Expedition. It was taken on the mesa near the mouth of Sabino Cañon, Santa Catalina Mountains, Arizona.

Description of Specimen.— The single specimen obtained of this well known form seems to be entirely normal and needs no description.

Habitat Relations.— It seems strange that practically nothing has been recorded on the habitat of such a well known animal as the Gila Monster. About Tucson we found that its principal habitat was the alluvial slope at the foot of the Santa Catalina Mountains (Suaharo-Ocotillo association), where it is quite common. In four weeks collecting none were seen by us on the plains in this region, and Prof. Thornber informed us that specimens were only very rarely secured in this habitat.

In spite of the sluggishness usually attributed to the Gila Monster it can fight fiercely, and when angered displays an unexpected agility in view of its awkward appearance. The specimen captured when seized with long forceps struggled fiercely, snapping and hissing, and throwing its head from side to side with surprising swiftness. When its teeth came in contact with any object, such as the side of the bag into which we were endeavoring to place it, it held on with bulldog tenacity, making it necessary to pry open the jaws to free the bag.

Van Denburgh,[1] writing on the much debated question of the venomous nature of the bite of this reptile, states that "The Gila Monsters are the only lizards whose bite is known to be poisonous. The venom is secreted by large glands situated just under the chin, and flows out, onto the floor of the mouth between the lips and the gums. Being below the teeth and not directly communicated to them, the poison sometimes fails to find its way into a wound although the teeth are grooved to afford it a passage." He further remarks in regard to its food habits that "In spite of its clumsy form it sometimes climbs bushes, probably in search of bird's eggs, which, together with young rabbits, etc., form its food."

Range.— As known at present the range of *H. suspectum* is quite limited. Living specimens seem to have been obtained only in southwestern Arizona, and in the northwestern part of the State of Sonora in Mexico. The southern extent of its range is unknown. That it ranges farther northward in the basins of the Proplateau region, seems to be indicated by the finding of a dead specimen in the valley of the Virgin River in southern Nevada.[2] However, the extent of its occurrence in this region has not as yet been ascertained. It is thus to be considered as a form of the Sonoran Desert, which, with *Callisaurus ventralis* and *Phrynosoma solare*, only enters the margin of the Proplateau region.

Cnemidophorus gularis *Baird & Girard.*

Cnemidophorus gularis Baird & Girard, Proc. Acad. Nat. Sci. Phila., 1852, 128.— Baird & Girard, Marcy's Explor. Red Riv., 1854, 210–211.— "Hallowell, Proc. Acad. Nat. Sci. Phila., 1856, 239."— Baird, U. S. and Mex. Bound. Surv., II, 1859, 11.— Baird, Rept. Pac. R. R. Surv., X (Whipple-Ives Route), 1859, 38.— Van Denburgh, Proc. Calif. Acad. Sci., Ser. 2, VI, 1896, 342–343.— Stejneger Proc. U. S. Nat. Mus., XXV, 1902, 151.— Stone & Rehn, Proc. Acad. Nat. Sci. Phila., 1903, 32–33.— Stone, *ibid.*, 540–541.— Bailey, North Amer. Fauna, No. 25, 1905, 44.

Cnemidophorus gularis gularis Cope, Proc. Acad. Nat. Sci. Phila., 1892, 334. — Cope, Rept. U. S. Nat. Mus., 1898 (1900), 602–605.

[1] Occ. Papers Calif. Acad. Sci., V, 122.
[2] North Amer. Fauna, No. 7, 194–195.

Cnemidophorus sexlineatus gularis Cope, Proc. Acad. Nat. Sci. Phila., 1866, 303–304.— Coues, Wheeler's Surv. West of 100th Merid., V, 1875, 602–603.— Cope, Bull. U. S. Nat. Mus., XXXII, 1887, 44.

Cnemidophorus guttatus Hallowell, Proc. Acad. Nat. Sci. Phila., 1854, 192.

Cnemidophorus gularis scalaris Cope, Rept. U. S. Nat. Museum, 1898 (1900), 605–607. (Part.)

Cnemidophorus scalaris Van Denburgh, Proc. Calif. Acad. Sci., Ser. 2, VI, 1896, 343–344.

Cnemidophorus sexlineatus Yarrow, Wheeler's Surv. West of 100th Merid., V, 1875, 557–558.— Cope, Bull. U. S. Nat. Museum, I, 1875, 45. (Part.)— Yarrow, *ibid.*, XXIV, 1883, 84, 3–44. (Part.)— Boulenger, Cat. of Lizards in Brit. Museum, II, 1885; 364–365. (Part.)

Locality.— *Cnemidophorus gularis* was found to be common in suitable habitats both at Alamogordo and Tucson.

Description of Specimens.— In scutellation this species is distinguished with difficulty from *C. sexlineatus*. In *C. gularis* the scales on the gular fold (especially the marginal row) are generally relatively larger than in *C. sexlineatus*, and there is always in *C. gularis* one or two rows of enlarged scales on the posterior face of the forearm (separating the minute dorsal and ventral scales) which are either absent in *C. sexlineatus* or when present much smaller than in the former species. These characters are unsatisfactory, however, the better marked characteristics being in the coloration. These are: (1) In the adults of *C. gularis* the pattern always consists of stripes and spots as described below, while in *C. sexlineatus* it is composed of stripes only. (2) In *C. gularis* the members of the dorsal pair of stripes are closer together than in *C. sexlineatus* (not considering the median dorsal line), the interspace being as narrow or narrower than the adjacent lateral one in the former species, generally wider in the latter.

There is considerable variation in size among Tucson specimens, so much so, in fact, as to have caused their reference to different species. Stejneger after an examination of specimens in this collection, both from Alamogordo and Tucson, still considers the eastern and western individuals as all belonging to a single form (*C. gularis*) as he has always done, but Cope [1] and Van Denburgh [2] have both referred the larger Tucson specimens to *C. scalaris*, although both record *C. gularis* from the same region.

From our series it is evident that there is but one species at Tucson, and that the specimens referred to typical *C. gularis* by Van Denburgh and Cope are in reality not full grown specimens. Since individuals of this size are generally indistinguishable from Alamogordo specimens I have no hesitancy in referring them to the same species. The difference between

[1] Rept. U. S. Nat. Mus., 1898, 606.
[2] Proc. Calif. Acad. Sci., Ser. 2, VI, 341.

them lies in the fact that while those from Tucson may grow to a total length of 400 mm. and over, I am convinced that Alamogordo specimens seldom exceed 280 mm. in length. This difference I believe may be attributed to differences in the nature of the habitat, as stated below. Femoral pores 16–21 (usual number 18 or 19).

The color descriptions are as follows:

(*a*) Young specimens from Tucson (body length 35 mm.). Above black with six longitudinal lines of pale bluish white, but no spots. The median dorsal pair of stripes end at the cephalic plates, the second on either side is continued above the eye, the lowest above the ear to the eye. Head dark brown. Limbs pale brown marbled with darker, a pale line along the posterior face of the thigh. Tail light reddish, the light and dark bands of the dorsal surface plainly indicated on its base. Belly white.

(*b*) Adult specimens from Alamogordo (body length 85 mm.). Dorsal surface reddish brown with six greenish or light reddish brown stripes, separated by one or more irregular rows of rounded pale orange spots. The ground color of the limbs above is the same as that of the dorsal surface of the body, and is spotted with lighter. Tail light brown. The members of the median pair of stripes are as a rule close together, but may be separated more widely and have a row of spots in the interspace.

(*c*) Medium sized specimens from Tucson (body length 80–90 mm.). The same as *b* except that the ground color may be black, and the median pair of dorsal stripes are usually wider apart with a row of light spots in the interspace. Stripes in the darker specimens bright greenish yellow.

(*d*) Large specimens from Tucson (body length 125 mm.). In the largest specimens from this locality the ground color is very dark reddish brown or black, and the stripes (beginning anteriorly) are nearly or entirely broken up into spots. Spots greenish blue. Neck uniformly dark reddish brown, with or without faint indications of the usual longitudinal stripes.

Habitat Relations.— Alamogordo. At Alamogordo this lizard was found only in the lower part of the cañons, and in the stony arroyos on the alluvial slopes (Fig. 8). Its habitat is thus quite distinct from that of *C. sexlineatus* which is found only on the plains.

Tucson. At Tucson it occurs likewise in the lower part of the cañons, and follows down the arroyos on the slopes to the Santa Cruz River where it is a characteristic reptile in the Willow-Poplar association on the banks.

While it thus occupies the same topographic features in the two localities, the other environmental conditions are sufficiently dissimilar to make the habitat a very different one in the two regions. This is well illustrated by the plants. At Alamogordo the vegetation consists of the Sotol, Ocotillo, various cacti, yuccas, etc., and the habitat is a very open and arid one, while

at Tucson the vegetation consists of trees and bushes, and the habitat is the most shaded and protected one below the Piñon-Cedar association. It may or may not be significant that the only specimen taken in a dry arroyo at Tucson (vegetation Ocotillo, cacti, etc.) is a "medium sized" individual with both stripes and spots, while the largest specimens were only found in the Willow-Poplar association along the streams. At any rate it is conceivable that the environmental conditions at Tucson may be more favorable for this species than those composing its habitat at Alamogordo, and thus be directly or indirectly the cause of the larger size attained by individuals in this locality. If this is the true explanation of the facts in the case it must be that the Alamogordo specimens are either inhibited from attaining a larger size by the exigencies of their habitat, or represent a dwarfed race.

In both localities *C. gularis* is strictly a ground form. At Alamogordo it is found among the rocks and clumps of yuccas, cacti, etc.; at Tucson about the bushes and weeds that form the underbrush in the Willow-Poplar association, and among the rocks in dry cañons. In the Willow-Poplar association it is difficult to secure owing to its shyness and the rapidity of its movements. The large individuals can often be heard several rods away rustling about in the leaves and brush, but they are almost constantly in motion and stay close to the protection of the bushes.

The food, as shown by the examination of a number of stomachs from both localities, consists entirely of insects; beetles and ants forming the bulk of the stomach contents.

Range.— The principal home of this species is the Proplateau region. It has been found in northern Mexico, southern Arizona, New Mexico, and western Texas. In Texas it has been recorded from as far east as Waco in the Prairie region, but the specimens upon which the central Texas records are based should be carefully reëxamined and distinguished from the western form of *C. sexlineatus* which occupies the same region (see p. 557). It has not been recorded from the Sonoran desert.

Cnemidophorus gularis Baird & Girard.

Habitat	Field No.	Locality	When Collected	Collector	Femoral Pores
		Alamogordo, N. M.			
Creosote Bush Assn.	98	Alluvial slope east of Alamogordo	July 8–06	G. von Krockow	18–19
"	160	"	July 11–06	A. G. Ruthven	18–?
"	161	"	"	"	18–19
"	162	"	"	A. F. Zimmer	18–18

Habitat	Field No.	Locality	When Collected	Collector	Femoral Pores
Creosote Bush Assn.	163	Alluvial slope east of Alamogordo	July 11–06	A. F. Zimmer	18–19
Arroyo in Creosote bush Assn.	179	"	July 12–06	A. G. Ruthven	19–19
"	180	"	"	A. F. Zimmer	19–19
"	218	"	July 13–06	A. G. Ruthven	19–19
"	235	"	"	G. von Krockow	
"	236	"	"	"	18–19
"	237	"	"	"	18–18
"	238	"	"	"	
"	269	"	July 14–06	"	17–17
Sotol-Ocotillo Assn.	553	Dry Cañon east of Alamogordo	July 23–06	A. G. Ruthven	18–18
"	554	"	"	"	17–19
"	557	"	"	A. F. Zimmer	
"	558	"	"	"	18–19
"	560	"	"	G. von Krockow	18–18
"	561	"	"	"	18–19
"	586	"	July 24–06	"	18–20
"	587	"		"	18–?
		Tucson, Ariz.			
Willow-Poplar Assn.	608	Bank of Santa Cruz River	July 31–06	A. G. Ruthven	19–19
Suaharo-Ocotillo Assn.	663	Mesa west of Santa Cruz River	Aug. 3–06	"	18–19
Willow-Poplar Assn.	685	"	Aug. 5–06	"	19–20
"	687	"	"	G. von Krockow	
"	688	"	"	"	
"	750	Bank of Santa Cruz River	Aug. 8–06	A. G. Ruthven	19–19
"	824	"	Aug. 12–06	G. von Krockow	18–19
"	979	Near mouth of Sabino Cañon	Aug. 18–06	A. G. Ruthven	21–20
"	980	"	"	"	19–19
"	981	"	"	"	18–19
"	982	"	"	"	16–17
"	983	"	"	"	18–19
"	984	"	"	"	20–20

Cnemidophorus melanostethus *Cope.*

Cnemidophorus melanostethus Cope, Proc. Acad. Nat. Sci. Phila., 1863, 104; *ibid.*, 1866, 310.

Cnemidophorus tessellatus melanostethus Cope, Bull. U. S. Nat. Mus., I, 1875, 46.— Cope, Rept. U. S. Nat. Mus., 1898, (1900), 581–582.

Cnemidophorus tigris melanostethus Coues, Wheeler's Surv. West of 100th Merid., V, 1875, 603.— Yarrow, Bull. U. S. Nat. Mus., XXIV, 1883, 8, 45.— Van Denburgh, Proc. Calif. Acad. Sci., Ser. 2, VI, 1896, 344.— Stejneger, Proc. U. S. Nat. Mus., XXV, 1902, 151.

Locality.— Representatives of a series of 168 specimens from Tucson, Ariz., and 120 from Alamogordo, N. M., have been referred by Dr. Stejneger to this species. In both localities the species is very abundant in suitable habitats.

Description of Specimens.— The specimens of *Cnemidophorus* from Tucson and Alamogordo referred to this species apparently agree in scutellation. In both there are eight rows of ventral plates, and the scales of the gular region become granular on the edge of the fold. The specimens from the two localities differ so much in coloration, however, as to require separate descriptions.

In the Alamogordo specimens the ground color above is light chocolate brown to black, with very numerous, short narrow bands of lighter. These markings are grayish brown to dull orange yellow on the back, light bluish slate on the sides, and, although of varying length and irregularly disposed, are mostly transverse on the sides, becoming more or less confluent toward the middle of the back. The coalescing of the light dorsal markings occasionally give rise to an indistinct series of longitudinal stripes which are, however, much broken up. Head brown, without markings. Limbs above spotted with lighter. Tail without pattern, becoming dark brown toward the tip. Belly white, the two external rows of scales on either side often tinged with pink, the central four with green. Throat and breast white, grayish white or bluish gray, spotted with black and often tinged with pink or yellow, but never entirely black.

Unfortunately no very young specimens were secured so that the development of the pattern cannot be followed as in Tucson specimens. But between individuals with a body length of 55–60 mm. and the largest adults there is little difference in coloration.

In the specimens from Tucson the ground color above is dull reddish brown to blackish brown, divided into longitudinal bands by four narrower and lighter stripes which vary in color from light ash to dull orange yellow. Between each pair of light stripes the ground color is relieved by small rounded spots similar in color to the stripes and arranged more or less irregularly in a single row. On the sides below the stripes the pattern consists of rather large and well defined white or light reddish gray spots on the dark ground which is occasionally broken up into black spots by the confluence of the light markings. On the superior surface of the limbs the light spots are mostly large and abundant enough to constrict the ground color to reticulations. The pattern of the dorsal surface of the body is occasionally continued onto the base of the tail but only indistinctly. The usual color of the tail is dark greenish yellow or light brown, mottled with

darker at the base, and becoming uniformly reddish brown toward the tip. The head is dull greenish yellow above in the paler specimens, light to dark chocolate in the darker ones, and without markings except for the slight difference in the intensity of the color on different parts of the head in the darker specimens. The mottled pattern of the sides of the body is continued onto the sides of the head. The lower labials are light gray, purple or bluish black, the throat, breast and under surface of the fore limbs entirely black, or mottled with black, gray or reddish. Posteriorly the black pigment becomes more and more restricted to the base of the scales, the prevailing color being white or yellowish. The posterior half of the belly and the under surfaces of the hind limbs and tail may be entirely white of yellowish, but are also frequently marked with black.

In very young specimens from Tucson there is another light stripe on either side, extending from below the eye and above the shoulder to the lateral abdominal region. The ground color is jet black, the stripes pale orange yellow, and there is a U-shaped mark of the latter color embracing the parietal plate. There are light spots on either side of the lowest lateral stripes but none between the upper four. Dorsal pattern continued distinctly onto the base of the tail, the extremity of which is uniformly light blue. Limbs black above, spotted with lighter. Ventral surface white, throat faintly mottled with darker.

Changes leading to the adult coloration appear very early. Faint spots make their appearance between the four dorsal stripes, the lowest stripe on either side breaks up into light rounded spots similar to the other light spots adjacent to them, and those on the limbs expand to restrict the ground color to a network. But although even in the very young specimens (body length 30–35 mm.) the throat is slightly mottled with darker, it is not until a considerable size (body length 60–70 mm.) has been attained that it begins to be generally suffused with black.

In the largest specimens from Tucson the four dorsal stripes are faint, and the lower one on either side is occasionally very obscure except for rounded spots of lighter at intervals. In none of the specimens are they entirely wanting, however. The form may thus be easily distinguished from the Alamogordo type by the dorsal pattern of light stripes, and rounded, generally well defined light spots, and the black throat in adults; the Alamogordo specimens, as above decribed, having the light markings in the form of short bars, which seldom, and then but imperfectly, fuse to form longitudinal stripes, while the throat is only spotted and never suffused with black. In my opinion these differences at least indicate two distinct varieties.

Habitat Relations.— Alamogordo. The habitat of this lizard at Alamogordo is very well defined, as it is found in the Creosote bush association on the alluvial slopes and only slightly exceeds the limits of this habitat. It is very common in this habitat, being as characteristic of these conditions as is the Creosote bush. It is a ground form, and is most frequently seen running about between the bushes picking up grasshoppers, beetles, locusts and ants, which constitute the bulk of its food. The stomach of one individual contains a large number of winged ants. When frightened they do not, as the smaller lizards, seek concealment in the nearest bush, but dash away swiftly for several rods before stopping. They generally stop near a bush, however, and after looking about for a moment or two slip quietly into it, frequently leaving it directly again on the other side for a neighboring one. This may be repeated several times, making it difficult to secure them.

At Tucson *C. melanostethus* is common and of general distribution on the Greasewood plains. It is also found on the mesas, but more abundantly in the Creosote bush association in the arroyos, and much less commonly in the Suaharo-Ocotillo association of the hills. Its food, as shown by an examination of stomach contents, seems to consist of insects exclusively — ants, beetles, grasshoppers and spiders being recognizable. It is in turn, according to our observations, preyed upon by the Arizona Racer (*Bascanion flagellum frenatum*) and the Leopard Lizard (*Crotaphytus wislizenii*).

Range.— It will be impossible to define the range of this species until the status of the different forms has been established. The name has heretofore been restricted to southern Arizona specimens.

Cnemidophorus melanostethus Cope.

Habitat	Field No.	Locality	When Collected	Collector	Femoral Pores
		Alamogordo, N. M.			
Between the Creosote bush and Mesquite Assns.	82	Lower margin of alluvial slope east of Alamogordo	July 7–06	A. G. Ruthven	23–23
"	94		July 8–06	G. von Krockow	24–23
"	95	"	"	"	21–21
"	96	"	"	"	21–24
"	97	"	"	"	
"	99	"	"	"	23–23
"	101	"	July 11–06	A. G. Ruthven	21–23
"	164	"	"	G. von Krockow	23–23
"	166	"	"	"	22–24
"	168	"	"	"	20–21
"	169	"	"	"	20–22
"	170	"	"	"	21–21
"	172	"	"	"	20–23

Habitat	Field No.	Locality	When Collected	Collector	Femoral Pores
Creosote bush Assn.	181	Alluvial slope east of Alamogordo	July 21–06	A. G. Ruthven	20–22
"	183	"	"	"	20–22
"	184	"	"	"	23–23
"	185	"	"	"	22–22
"	186	"	"	"	
"	187	"	"	"	23–24
"	188	"	"	"	22–22
"	189	"	"	"	22–23
"	190	"	"	"	20–20
"	192	"	"	G. von Krockow	25–26
"	193	"	"	"	23–23
"	194	"	"	"	
"	195	"	"	"	22–25
"	196	"	"	"	22–24
"	197	"	July 13–06	A. G. Ruthven	
"	198	"	"	"	23–23
"	199	"	"	"	21–21
"	200	"	"	"	21–24
"	201	"	"	"	22–22
"	202	"	"	"	22–24
"	203	"	"	"	21–22
"	204	"	"	"	22–23
"	205	"	"	"	22–23
"	206	"	"	"	20–21
"	207	"	"	"	21–22
"	208	"	"	"	22–24
"	209	"	"	"	25–26
"	210	"	"	"	20–23
"	211	"	"	"	22–23
"	212	"	"	A. F. Zimmer	22–24
"	213	"	"	"	23–24
"	214	"	"	"	22–23
"	215	"	"	"	23–24
"	216	"	"	"	22–23
"	217	"	"	"	
"	220	"	"	G. von Krockow	21–21
"	221	"	"	"	24–24
"	222	"	"	"	20–22
"	223	"	"	"	22–23
"	224	"	"	"	21–21
"	225	"	"	"	22–24
"	226	"	"	"	21–23
"	227	"	"	"	21–23
"	228	"	"	"	20–20
"	229	"	"	"	19–19
"	230	"	"	"	21–23
"	231	"	"	"	22–23
"	232	"	"	"	
"	233	"	"	"	21–21
"	234	"	"	"	24–25
"	259	"	July 14–06	"	23–24
"	260	"	"	"	22–22
"	261	"	"	"	22–24
"	262	"	"	"	23–23
"	263	"	"	"	23–23

Habitat	Field No.	Locality	When Collected	Collector	Femoral Pores
Creosote bush Assn.	264	Alluvial slope east of Alamogordo	July 14–06	G. von Krockow	20–22
"	265	"	"	"	
"	266	"	"	"	24–24
Between the Creosote bush and Mesquite Assns.	267	Lower margin of alluvial slope east of Alamogordo	"	"	
"	268	"	"	"	22–22
"	270	"	"	"	24–24
"	272	"	"	A. G. Ruthven	22–22
"	273	"	"	"	20–21
Creosote bush Assn.	274	Alluvial slope east of Alamogordo	"	"	23–25
"	275	"	"	A. F. Zimmer	
"	276	"	"	"	22–24
"	277	"	"	"	20–22
"	288	"	July 15–06	A. G. Ruthven	23–24
"	289	"	"	"	22–23
"	290	"	"	"	22–22
"	291	"	"	"	21–24
"	296	"	"	G. von Krockow	
"	297	"	"	"	
"	298	"	"	"	22–22
"	299	"	"	"	21–23
"	300	"	"	"	25–25
"	301	"	"	"	
"	379	"	July 18–06	"	21–22
"	380	"	"	"	22–22
"	381	"	"	"	24–25
"	382	"	"	"	23–27
"	383	"	"	"	23–24
"	384	"	"	"	21–24
"	385	"	"	"	22–22
"	386	"	"	"	22–22
"	387	"	"	"	22–24
"	388	"	"	"	24–24
"	391	"	"	A. G. Ruthven	19–20
"	392	"	"	"	22–25
"	393	"	"	"	20–23
"	394	"	"	"	22–22
"	395	"	"	"	21–21
"	396	"	"	"	24–24
"	397	"	"	"	20–23
"	398	"	"	"	
"	399	"	"	"	20–21
"	400	"	"	"	22–22
"	401	"	"	"	24–26
"	402	"	"	"	22–23
"	403	"	"	"	24–24
"	404	"	"	"	23–24
"	405	"	"	"	22–22
"	406	"	"	"	20–20
"	407	"	"	A. F. Zimmer	22–23
"	408	"	"	"	20–21
"	409	"	"	"	

Habitat	Field No.	Locality	When Collected	Collector	Femoral Pores
Between the Creosote bush and Mesquite Assns.	498	Lower margin of alluvial slope southeast of Alamogordo	July 21–06	G. von Krockow	22–22
"	499	"	"	"	21–22
"	505	"	"	A. G. Ruthven	23–23
"	508	"	"	"	
"	510	"	"	"	22–23
Between the Creosote bush and Sotol-Ocotillo Assns.	555	Upper part of alluvial slope east of Alamogordo	July 23–06	"	24–25
"	562	"	"	G. von Krockow	23–24
"	588	"	July 24–06	"	
"	591	"	"	A. G. Ruthven	21–21
		Tucson, Ariz.			
Creosote bush Assn.	609	Mesa west of Santa Cruz River	July 31–06	G. von Krockow	20–19
"	610	"	"	"	19–20
"	611	"	"	"	19–19
"	612	"	"	"	19–20
"	613	"	"	"	20–21
"	614	"	"	"	21–21
"	615	"	"	"	19–19
"	629	"	Aug. 1–06	A. G. Ruthven	20–21
"	630	"	"	"	20–21
"	631	"	"	"	17–18
"	632	"	"	"	20–20
"	633	"	"	"	19–20
"	634	"	"	"	20–23
"	635	"	"	"	20–20
"	636	"	"	"	19–20
"	648	Plains southeast of Tucson	Aug. 2–06	"	19–20
"	649	"	"	"	19–20
"	650	"	"	"	18–19
"	651	"	"	"	
"	652	"	"	"	21–21
"	653	"	"	"	19–20
"	654	"	"	"	19–20
"	655	"	"	"	21–22
"	656	"	"	"	18–18
"	659	"	"	G. von Krockow	20–21
"	660	"	"	"	19–19
"	661	"	"	A. F. Zimmer	21–22
Suaharo-Ocotillo Assn.	662	Mesa west of Santa Cruz River	Aug. 3–06	A. G. Ruthven	20–21
"	664	"	"	"	19–20
"	665	"	"	"	22–21
"	666	"	"	A. F. Zimmer	22–24
"	668	Mesa west of Santa Catalina Mts.	Aug. 4–06	G. von Krockow	18–19
"	669	"	"	"	19–20
"	670	"	"	A. G. Ruthven	21–21
"	671	"	"	"	19–19

Habitat	Field No.	Locality	When Collected	Collector	Femoral Pores
Suaharo-Ocotillo Assn.	672	Mesa west of Santa Catalina Mts.	Aug. 4–06	A. G. Ruthven	18–18
"	673	"	"	"	
Creosote bush Assn.	690	Mesa west of Santa Cruz River	Aug. 5–06	G. von Krockow	21–21
"	698	Plains east of Tucson	Aug. 6–06	A. G. Ruthven	19–20
"	699	"	"	"	
"	700	"	"	"	
"	701	"	"	"	
"	702	"	"	"	23–24
"	703	"	"	"	19–19
"	704	"	"	"	19–20
"	705	"	"	"	22–22
"	706	"	"	"	22–22
"	707	"	"	"	20–21
"	708	"	"	A. F. Zimmer	23–24
"	709	"	"	G. von Krockow	23–24
"	710	"	"	"	23–24
"	711	"	"	"	19–20
"	712	"	"	"	
"	713	"	"	"	
"	716	"	Aug. 7–06	A. G. Ruthven	19–20
"	717	"	"	"	20–23
"	718	"	"	"	19–20
"	719	"	"	"	19–20
"	720	"	"	"	19–20
"	721	"	"	"	22–23
"	722	"	"	"	20–20
"	723	"	"	"	22–23
"	724	"	"	"	21–21
"	730	"	"	"	
"	731	"	"	"	
"	732	"	"	"	
"	733	"	"	"	
"	738	"	"	A. F. Zimmer	
"	739	"	"	G. von Krockow	18–19
"	740	"	"	"	19–22
"	741	"	"	"	19–19
"	742	"	"	"	21–21
"	743	"	"	"	22–24
"	744	"	"	"	17–20
Between the Creosote bush and Mesquite Assns.	753	Near Santa Cruz River	Aug. 8–06	A. G. Ruthven	
"	755	"	"	"	20–21
"	757	"	"	A. F. Zimmer	26–24
"	759	"	"	G. von Krockow	20–22
"	762	"	"	"	21–21
Atriplex Assn. on Salt Spot.	769	Mesa west of Santa Cruz River	Aug. 9–06	A. G. Ruthven	
Creosote bush Assn.	770	"	"	"	18–19
"	771	"	"	"	21–21
"	772	"	"	"	20–21

Habitat	Field No.	Locality	When Collected	Collector	Femoral Pores
Mesquite Assn.	778	Near Santa Cruz River	Aug. 9–06	A. G. Ruthven	18–19
"	779	"	"	"	
Atriplex Assn. on Salt Spot	780	Mesa west of Santa Cruz River	"	G. von Krockow	21–21
"	784	"	"	A. F. Zimmer	18–19
Creosote bush Assn.	787	Plains southwest of Fort Lowell	Aug. 10–06	A. G. Ruthven	19–22
"	788	"	"	"	20–21
"	789	"	"	"	20–20
"	790	"	"	"	23–24
Mesquite Assn.	791	Bank of Pantano Wash east of Fort Lowell	"	"	
Creosote bush Assn.	794	Plains south of Fort Lowell	"	G. von Krockow	22–22
"	800	Plains east of Tucson	Aug. 11–06	A. G. Ruthven	20–20
"	801	"	"	"	21–21
"	802	"	"	"	18–19
"	803	"	"	"	19–21
"	806	"	"	A. F. Zimmer	19–19
"	807	"	"	"	19–20
"	608	"	"	"	22–23
"	810	"	"	G. von Krockow	20–20
"	811	"	"	"	21–21
Willow-Poplar Assn.	825	Bank of Santa Cruz River	Aug. 12–06	"	22–22
"	826	"	"	"	
Creosote bush Assn.	827	Plains northeast of Tucson	Aug. 13–06	A. G. Ruthven	19–22
"	828	"	"	"	21–22
"	829	"	"	"	
"	830	"	"	"	20–20
"	831	"	"	"	20–21
"	832	"	"	"	20–22
"	833	"	"	"	19–19
"	836	"	"	A. F. Zimmer	18–18
"	837	"	"	G. von Krockow	21–21
"	838	"	"	"	
"	845	Mesa west of Santa Cruz River	Aug. 14–06	"	19–22
"	847	"	"	"	21–21
"	848	"	"	"	21–21
"	849	"	"	"	19–20
"	850	"	"	"	19–19
"	851	"	"	"	20–21
Between the Creosote bush and Mesquite Assns.	858	Near Santa Cruz River	"	A. F. Zimmer	
"	859	"	"	"	
Mesquite Assn.	861	"	"	A. G. Ruthven	19–21
"	862	"	"	"	
"	863	"	"	"	
Creosote bush Assn.	869	Mesa west of Santa Cruz River	"	"	17–19

Habitat	Field No.	Locality	When Collected	Collector	Femoral Pores
Creosote bush Assn.	870	Mesa west of Santa Cruz River	Aug. 14–06	A. G. Ruthven	17–18
"	871	"	"	"	18–19
"	872	"	"	"	19–19
"	883	Plains east of Tucson	Aug. 15–06	"	19–20
"	884	"	"	"	20–21
"	885	"	"	"	16–17
"	886	"	"	"	20–20
"	887	"	"	"	
"	888	"	"	"	19–20
"	889	"	"	"	
"	890	"	"	"	
"	891	"	"	"	
"	893	"	"	A. F. Zimmer	20–21
"	894	"	"	"	
"	898	"	"	"	
"	904	"	"	G. von Krockow	
"	905	"	"	"	22–22
"	906	"	"	"	21–22
"	907	"	"	"	23–23
"	908	"	"	"	21–23
Suaharo-Ocotillo Assn.	911	Mesa west of Santa Cruz River	Aug. 16–06	A. G. Ruthven	20–20
"	912	"	"	"	19–20
"	913	"	"	"	20–21
"	914	"	"	"	20–20
"	915	"	"	"	20–20
Creosote bush Assn.	916	"	"	"	19–20
"	917	"	"	"	
"	923	"	"	A. F. Zimmer	
"	926	"	"	G. von Krockow	21–21
"	927	"	"	"	22–23
"	928	"	"	"	
Between the Creosote bush and Mesquite Assns.	945	Near Santa Cruz River	Aug. 17–06	"	20–21
"	946	"	"	"	19–19
"	947	"	"	"	20–21
"	948	"	"	"	20–20
"	949	"	"	"	21–21
"	950	"	"	"	20–20
"	958	"	"	A. G. Ruthven	20–21
"	959	"	"	"	21–21
"	960	"	"	"	21–21
Creosote bush Assn.	1004	Plains east of Tucson	Aug. 20–06	"	20–20
Suaharo-Ocotillo Assn.	1019	Mesa west of Santa Cruz River	Aug. 21–06	A. F. Zimmer	18–20
"	1020	"	"	"	18–20

Cnemidophorus sexlineatus *Linnæus.*

Locality.— Specimens of *C. sexlineatus* were taken at Alamogordo, N. M., where it is a common reptile.

Description of Specimens.— The structural characters of this species have been considered under *C. gularis.* Size smaller than *C. gularis,* the largest individuals having a body length of 65–70 mm. The color pattern of the dorsal surface consists of 7 light stripes on a darker ground, the median dorsal one distinct or obscure but usually more indistinct posteriorly.

Specimens from the Mesquite Association. Ground color above a deep brown, stripes pale to bright golden yellow. No spots. Limbs above nearly uniformly brown, occasionally with a few lighter markings on the thighs. Tail distally bright blue. Head dark olive. The under surface of the limbs, base of tail, and usually the infralabials are white, the rest of the ventral surface bluish.

Specimens from the White Sands. Above pale brownish gray, stripes light bluish, mostly faint, occasionally entirely wanting. Head pale grayish olive. Tail light blue. Ventral surface of limbs, base of tail, and frequently the throat, white; under parts otherwise pale bluish.

Habitat Relations.— *C. sexlineatus* is a characteristic form of the desert floor habitats. In the Mesquite and Atriplex associations it was found commonly about the clumps of bushes that comprise the vegetation. On the White Sands it was also abundant, but apparently prefers the bottoms and lower parts of the dunes to the more exposed summits of the latter, being unlike *Holbrookia maculata flavilenta* in this respect. Its food consists of insects which it picks up on the ground. Ants, grasshoppers and spiders were found in the stomachs examined.

There has been considerable uncertainty as to the relationship of *C. gularis* and *C. sexlineatus* in New Mexico and central Texas. This has resulted from the fact that west of the 98th meridian *C. sexlineatus* approaches *C. gularis* so closely in appearance as to suggest either an intergradating or at least a close relationship between the two forms. At Alamogordo, which is near the western limit of *C. sexlineatus,* we found both forms perfectly distinct not only in the scutellation and color, as described under *C. gularis,* but by the fact that *C. gularis* is confined to the lower part of the cañons, and the stony arroyos on the alluvial slopes, while *C. sexlineatus* occurs only in the Mesquite, Atriplex and Sumac-Yucca associations on the plains.

If the habitats of the two species in Texas were known, it would probably be found that a similar habitat distribution exists in that region. The ranges of the two forms thus interdigitate for a long distance and intergradation very probably does not occur.

Range.—*Cnemidophorus sexlineatus* is a form of southeastern United States, ranging northward to about the 40th parallel. It is one of the few reptiles which crosses the 98th meridian in Texas, extending at least as far westward as the Rio Grande Valley [1] in New Mexico. The Arizona records known to me are too indefinite to be relied upon.

Cnemidophorus sexlineatus Linnæus.

Habitat	Field No.	Locality	When Collected	Collector	Femoral Pores
		Alamogordo, N. M.			
Mesquite Assn.	78	Plains south of Alamogordo	July 7–06	A. G. Ruthven	17–17
"	79	"	"	"	16–16
"	80	"	"	G. von Krockow	16–17
"	85	"	"	"	16–16
Between the Creosote bush and Mesquite Assns.	98	"	July 8–06	"	17–17
Mesquite Assn.	100	"	July 9–06	A. G. Ruthven	16–17
"	102	"	"	"	
"	103	"	"	"	14–14
"	104	"	"	"	
"	105	"	"	A. F. Zimmer	15–16
"	106	"	"	"	16–17
"	107	"	"	A. G. Ruthven	
Sumac-Yucca Assn.	116	White Sands west of Alamogordo	"	"	15–15
"	117	"	"	"	
"	118	"	"	A. F. Zimmer	13–14
"	119	"	"	"	
"	120	"	"	G. von Krockow	14–15
"	121	"	"	"	15–16
Mesquite Assn.	126	Plains south of Alamogordo	"	"	15–15
"	127	"	"	"	17–17
"	147	"	July 10–06	A. F. Zimmer	
"	156	"	July 11–06	A. G. Ruthven	14–15
"	157	"	"	"	14–15
"	165	"	"	G. von Krockow	
"	167	"	"	"	15–16
"	171	"	"	"	
"	191	"	July 12–06	A. F. Zimmer	17–17
"	271	"	July 14–06	A. G. Ruthven	15–15
"	305	Plains west of Alamogordo	July 16–06	"	17–18
"	306	"	"	"	14–15
Atriplex Assn.	307	"	"	"	14–14
"	308	"	"	"	17–17
"	309	"	"	"	16–16
"	310	"	"	"	15–15
"	311	"	"	"	

[1] Herrick, Terry and Herrick, Bull. Sci. Lab. Denison Univ., XI, 145–146.

Habitat	Field No.	Locality	When Collected	Collector	Femoral Pores
Atriplex Assn.	312	Plains west of Alamogordo	July 16–06	A. G. Ruthven	17–18
"	313	"	"	"	16–16
"	314	"	"	"	14–16
"	315	"	"	"	14–16
"	316	"	"	"	16–16
"	317	"	"	"	17–17
"	318	"	"	"	15–15
"	319	"	"	"	15–15
"	320	"	"	"	16–17
Between the Atriplex and Mesquite Assns.	321	"	"	A. F. Zimmer	13–14
"	322	"	"	"	15–16
"	323	"	"	A. G. Ruthven	16–16
"	324	"	"	"	
Mesquite Assn.	325	"	"	G. von Krockow	18–18
"	326	"	"	"	14–16
Atriplex Assn.	421	"	July 19–06	A. F. Zimmer	15–15
"	422	"	"	A. G. Ruthven	14–15
"	423	"	"	A. F. Zimmer	16–16
"	424	"	"	"	15–15
"	425	"	"	"	
"	428	"	"	"	15–15
"	429	"	"	"	15–15
"	430	"	"	"	14–14
"	431	"	"	A. G. Ruthven	15–15
"	432	"	"	"	17–17
"	433	"	"	"	13–15
"	434	"	"	"	15–16
Sumac-Yucca Assn.	441	White Sands west of Alamogordo	"	"	16–17
"	442	"	"	A. F. Zimmer	16–16
"	443	"	"	"	15–16
"	445	"	"	"	
"	446	"	"	"	12–14
"	447	"	"	A. G. Ruthven	15–15
Atriplex Assn.	449	Plains west of Alamogordo	"	"	15–15
"	450	"	"	"	16–17
"	452	"	"	"	16–16
"	453	"	"	A. F. Zimmer	
"	454	"	"	"	14–15
"	455	"	"	A. G. Ruthven	15–16
"	456	"	"	A. F. Zimmer	16–17
"	458	"	"	A. G. Ruthven	15–16
"	460	"	"	A. F. Zimmer	15–15
"	464	"	"	"	17–18
Summac-Yucca Assn.	470	White Sands west of Alamogordo	"	G. von Krockow	17–17
Atriplex Assn.	476	Plains west of Alamogordo	"	"	13–13
"	477	"	"	"	14–14
"	480	"	"	"	16–17
"	482	"	"	"	17–17

Habitat	Field No.	Locality	When Collected	Collector	Femoral Pores
Atriplex Assn.	483	Plains west of Alamogordo	July 19–06	G. von Krockow	15–16
"	486	"	"	"	
"	487	"	"	"	17–18
"	488	"	"	"	16–17
"	489	"	"	"	17–18
"	491	"	"	"	14–16
"	492	"	"	"	15–17
Sumac-Yucca Assn.	493	White Sands west of Alamogordo	"	A. G. Ruthven	16–17
Mesquite Assn.	500	Plains south of Alamogordo	Aug. 21–06	G. von Krockow	
"	501	"	"	"	14–15
"	504	"	"	"	15–15
"	506	"	"	"	14–15
"	509	"	"	A. G. Ruthven	16–18
"	511	"	"	"	16–17
"	512	"	"	A. F. Zimmer	14–14

SERPENTES.

Leptotyphylops[1] **humilis** *Baird & Girard.*

Rena humilis Baird & Girard, Cat. of North Amer. Reptiles, 1853, 143.— Cope, Bull. U. S. Nat. Museum, XXXII, 1887, 64.— Stejneger, Proc. U. S. Nat. Museum, XIV, 1891, 501.— Cope, *ibid.*, XIV, 1892, 590.— Stejneger, North Amer. Fauna, No. 7, 1893, 203.— Van Denburgh, Proc. Calif. Acad. Sci., Ser. 2, V, 1895, 136–137.

Stenostoma humile "Peters, Monatsberichte, 1857, 402."— Cope, Proc. Acad. Nat. Sci. Phila., 1861, 305; *ibid.*, 1866, 312.— Cope, Bull. U. S. Nat. Museum, I, 1875, 44.— Yarrow, *ibid.*, XXIV, 1882, 20, 142.— Garman, Mem. Mus. Comp. Zool., VIII, No. 3, 1883, 130.— "Belding, West Amer. Sci., III, No. 24, 1887, 98."

Glauconia humilis "Boulenger, Cat. of Snakes in Brit. Museum, I, 1893, 70."— Cope, Amer. Nat., XXX, 1897, 1014.— Cope, Rept. U. S. Nat. Museum, 1898 (1900), 719.— Brown, Proc. Acad. Nat. Sci. Phila., 1901, 14.

Siagonodon dugesii "Bocourt, Miss. Sci. Mex., Rept., 1882, 507."

Siagonodon humilis Van Denburgh, Occ. Papers Calif. Acad. Sci., V, 1897, 150–151.

Locality.— Two specimens (Nos. 1032 and 1033) of this curious little snake were presented to the expedition by Prof. Thornber.

[1] I am not able to find sufficient differences between *Leptotyphylops dulcis* and *Rena humilis* to warrant their generic separation. These forms are evidently closely related and while *L. dulcis* occurs from western Texas to central New Mexico, *L. humilis* ranges from Tucson westward to California. The region where the ranges of the two forms come together is, therefore, extreme southeastern Arizona or southwestern New Mexico. The case thus seems to be analogous to that of *Salvadora grahamiæ* and *S. hexalepsis* and lends weight to the argument that they are nearly related species of the same genus.

Description of Specimens.— Body slender and vermiform; tail short and blunt; head not differentiated from body. Body covered with smooth, imbricate scales in 14 longitudinal rows, the terminal caudal scale ending in a short spine. Anal plate entire. The snout is protruding, considerably overlapping the mouth. The rostral is large and strongly recurved. Behind it is a single series of scales which is continuous with the median row of dorsal scales, and separates the corresponding lateral head plates of each side. The latter consist of: 1st, a large nasal extending to the mouth, and divided by a suture that extends between the nostril and the adjacent angle of the following plate; 2nd, a small supralabial plate bounded above and anteriorly by the nasal; 3rd, a large ocular that extends from the median cephalic series to the mouth, and beneath which may be seen the eye; 4th, a second and last small supralabial; 5th, a large plate situated above the last supralabial and followed by a 6th which is rather smaller.

Habitat Relations.— That this snake is a burrowing form is very evident from its partly concealed eyes and general vermiform shape. The specimens secured from Prof. Thornber were found with several others in a pile of manure on the Greasewood plains east of Tucson. Van Denburgh [1] states that in the "Cape Region" of Lower California this species "lives both in the mountains, and at the level of the sea."

Range.— This species is known to occur in the Proplateau region by the fact that specimens have been taken at Tucson, Ariz., and in southern California north to Death Valley. To the southward it extends to the southern end of the peninsula of Lower California, and in Mexico to Colima on the coast slope of the Sierra Madres.

Bascanion piceum *Cope.*

Bascanium flagelliforme piceum Cope, Bull. U. S. Nat. Mus., I, 1875, 40.— Coues, Wheeler's Surv. West of 100th Merid., V, 1875, 617.— Yarrow, Bull. U. S. Nat. Mus., XXIV, 1883, 16, 111.

Zamenis flagellum piceus Cope, Rept. U. S. Nat. Mus., 1898 (1900), 804–805.— Brown, Proc. Acad. Nat. Sci. Phila., 1901, 61.

Bascanion piceum Cope, Bull. U. S. Nat. Mus., XVII, 1880, 24.— Cope, Proc. U. S. Nat. Mus., XIV, 1892, 625.— Stejneger, North Amer. Fauna, No. 7, 1893, 209.— Van Denburgh, Proc. Calif. Acad. Sci., Ser. 2, VI, 1896, 347.

Locality.— A single specimen (No. 639) of this snake was secured, on the mesa west of Tucson, Ariz. It is apparently the fourth specimen of this species to be recorded, three of these being from Tucson.

Description of Specimen.— Adult, total length 1440 mm., tail length

[1] Proc., Calif. Acad. Sci., Ser. 2, V, 136.

345 mm. Scale formula 19–17–15–13, the 19 only extending to a point 95 mm. from the end of the snout. Scales smooth. Cephalic plates normal. Supralabials 8, infralabials 11. Oculars 1–2. An anterior subocular on either side. Form long and slender; gastrosteges 199, urosteges in 105 pairs. Anal divided.

Body and tail above, broadly including the ends of the ventral scutes, blue black without markings. Head dark brown with a few irregular reddish markings above. The loreals, preoculars and postoculars, and first six supralabials have bright orange yellow centers. Anterior part of throat marbled with bright yellow and black. Throat black with scattered spots of yellowish orange. About the twentieth gastrostege the light color increases in amount and the black becomes restricted to small blotches that become fewer posteriorly, only a few small, widely scattered spots being present on the posterior three-fourths of the body length and none on the tail. For most of the length the belly is a yellow orange tint, becoming a dark orange tint on the posterior one-fourth of the body and on the tail.

Habitat Relations.— The single specimen obtained was shot in the Suaharo-Ocotillo association on the mesa west of the Santa Cruz River. Nothing is known of the habits of the species.

Range.— The four specimens of *B. piceum* now known were all taken in the Proplateau region of southern Arizona, three of them in the immediate neighborhood of Tucson, the other at Camp Grant, Graham County.

Bascanion flagellum frenatum *Stejneger.*

Masticophis testaceus Cope, Proc. Acad. Nat. Sci. Phila., 1866, 305, 312.

Bascanion testaceum Cope, Proc. Acad. Nat. Sci. Phila., 1883, 11, 29, 32.

Bascanium flagelliforme testaceum Cope, Bull. U. S. Nat. Mus., I, 1875, 40. (Part at least.) — Yarrow, Wheeler's Surv. West of 100th Merid., V, 1875, 542.— Coues, *ibid.*, 617.— Yarrow, Bull. U. S. Nat. Mus., XXIV, 1883, 17, 111–112. (Part.)— Cope, Proc. Amer. Phil. Soc., 1885, 284.— "Belding, West Amer. Sci., III, No. 24, 1887, 89."— Cope, Bull. U. S. Nat. Mus., XXXII, 1887, 71.

Coluber flagelliformis testaceus Garman, Mem. Mus. Comp. Zool., VIII, No. 3, 1883, 148.

Bascanion flagelliforme Cope, Proc. U. S. Nat. Mus., XIV, 1892, 625–626. (Part.)

Herpetodryas flavigularis Hallowell, Rept. Pac. R. R. Surv., X (Williamson's Route), 1859, 12–13.— Heerman apud Hallowell, *ibid.*, 24.

Zamenis flagellum flagellum Cope, Rept. U. S. Nat. Mus., 1898, 799–803. (Part.)

Bascanion flagellum Meek, Field Museum of Nat. Hist., Zool. Series, VII, 1906, 15.

Bascanion flagellum frenatum Stejneger, North Amer. Fauna, No. 7, 1893, 208–209.— Van Denburgh, Proc. Calif. Acad. Sci., Ser. 2, V, 1895, 147–148.; *ibid.*, VI, 1896, 347.— Van Denburgh, Occ. Papers Calif. Acad. Sci., V, 1897, 186–188. —Stejneger, Proc. U. S. Nat. Mus., XXV, 1902, 155.

Zamenis flagellum frenatus Brown, Proc. Acad. Nat. Sci. Phila., 1901, 60–61.

Locality.— One specimen of this Racer (No. 966) was shot by Mr. Zimmer on the Greasewood plains, one mile south of Tucson. Several others were seen at various times.

Description of Specimen.— Adult. Form slender; total length 1140 mm., tail 300 mm. Dorsal scale formula 17–15–13, scales all smooth. Supralabials 8, infralabials 11. One anterior subocular. Oculars 1–2. Gastrosteges 193, urosteges 104, anal plate divided.

Above, except for a short distance anteriorly, the color is yellowish brown, relieved by small, mostly concealed bars of whitish that margin each scale on either side of the base. On the anterior half of the body, the base of nearly every scale is black, although the light lines are still present, occasionally being of a pinkish tint. On the neck the light marks tend to break up the ground color into cross bands, but only five or six of these are distinct, the anterior four being nearly solid black.

On either side of the belly there is a series of blotches similar in color to the dorsal surface, except anteriorly where they are black. Between this series of gastrostegeal spots and the first row of scales, which also has the color of the dorsal surface, is a white line that includes the tips of the gastrosteges and the lower edge of the first row of dorsal scales. Similarly the light marks on the bases of the scales of the first and second rows are somewhat better developed than those above, which also results in the appearance of a narrow light longitudinal line, but this is very indefinite. The top of the head is light brown, the sides considerably variegated with yellow.

The belly is light yellow, with the marginal series of blotches mentioned above. Interior to these blotches there is also, for about the anterior four-fifths of the length, a second row of small spots. The throat is also light yellow, and thickly spotted with black. The ventral surface of the tail is a light orange tint, immaculate.

Habitat Relations.— In this form, as in the other species of the genus, a slender form and long tail accompany a remarkable agility of movement and dexterity in climbing about in bushes. We only observed it on the Greasewood plains (Creosote bush association), where several individuals eluded us by their swiftness.

No observations on food habits were made other than that an individual was seen to capture an adult *Cnemidophorus melanostethus,* but it doubtless lives largely on small birds and mammals. Stejneger records a specimen which had eaten a mouse (North Amer. Fauna, No. 7, 209).

Range.— Stejneger[1] gives the range of *B. f. frenatum* as "Southern

[1] North Amer. Fauna, No. 7, 208.

Arizona, Utah, Nevada, California, and Lower California." To the southward it occurs throughout the length of the peninsula of Lower California, and to an undetermined distance on the plateau and western coastal slope of Mexico.

In southern New Mexico or western Texas it intergrades with typical *Bascanion flagellum* which ranges to the eastward.

Salvadora hexalepis *Cope.*

Salvadora grahamiæ Cope, Bull. U. S. Nat. Mus., XXXII, 1887, 72. (Part at least.)— Cope, Proc. U. S. Nat. Mus., XIV, 1892, 619–620. (Part.)— Van Denburgh, Proc. Calif. Acad. Sci., Ser. 2, V, 1895, 146–147; *ibid.*, VI, 1896, 347.— *ibid.*, V, 1896, 1006.— Van Denburgh, Occ. Papers Calif. Acad. Sci., V, 1897, 181–182.— Cope, Rept. U. S. Nat. Mus., 1898 (1900), 818–820. (Part.)— Brown, Proc. Acad. Nat. Sci. Phila., 1901, 63–64. (Part.) — Meek, Field Museum of Nat. Hist., Zool. Series, VII, 1906, 15.

Phimothyra grahamiæ Cope, Proc. Acad. Nat. Sci. Phila., 1861, 300.— Yarrow, Wheeler's Surv. West of 100th Merid., V, 1875, 538–539.— Coues, *ibid.*, 620.— Cope, Proc. Acad. Nat. Sci. Phila., 1883, 14.— Yarrow, Bull. U. S. Nat. Mus., XXIV, 1883, 98. (Part.)— "Belding, West Amer. Sci., III, No. 24, 1887, 98."

Salvadora grahami Jan, "Icon. Gen. Ophid., Pt. 1, 1860, fig. 1."

Phimothyra grahamiæ Cope, Proc. Acad. Nat. Sci. Phila., 1861, 300.

Phimothyra hexalepis Cope, Proc. Acad. Nat. Sci. Phila., 1866, 304.

Phimothyra grahamiæ hexalepis Coues, Wheeler's Surv. West of 100th Merid., V, 1875, 620.— Yarrow, Bull. U. S. Nat. Mus., XXIV, 1883, 15.

Salvadora grahamiæ hexalepis Cope, Bull. U. S. Nat. Mus., I, 1875, 38.— Garman, Mem. Mus. Comp., Zool., VIII, No. 3, 1883, 145.— Stejneger, North Amer. Fauna, No. 7, 1893, 205–206.

Salvadora hexalepis Stejneger, Proc. U. S. Nat. Mus., XXV, 1902, 154–155.

Locality.— A specimen (No. 1034) of this snake taken on the plains east of Tucson, was presented to the expedition by Prof. Thornber.

Description of Specimen.— This individual possesses all of the characters of the western as distinguished from the eastern species of the genus.[1] It also exhibits the tendency toward the breaking up of the lateral head plates, shown by Stejneger to be characteristic of western examples of the genus, which was the basis of the original description of *S. hexalepis* (*Phimothyra hexalepis*). The cephalic plates are normal. The rostral is very large with free lateral edges and is recurved on the top of the snout. There are two distinct nasal plates, and one loreal, one preocular, two postoculars, two anterior temporals, 9–10 supralabials and 11 infralabials. The symphyseal plate is small, but the first pair of inferior labials are much elongated posteriorly and broadly in contact mesially. The first pair of genials are also in

[1] Stejneger, Proc. U. S. Nat. Museum, XXV, 154–155.

contact, but the scutes of the second pair are separated by two rows of small scales anteriorly and four posteriorly.

The breaking up of the lateral head plates alluded to above is largely confined to the supralabials, as seems generally to be the case. If they were "normal" in this specimen there would be nine on each side (the seventh on the right side is anomalously divided, making ten in this series), and the anterior half of the first, and the second supralabials would be in contact above with the prenasal, the posterior half of the second and the anterior half of the third with the postnasal, the posterior half of the third and the anterior half of the fourth with the loreal, the posterior half of the fourth and the anterior half of the fifth with the preocular, the posterior half of the fifth and the anterior half of the sixth with the orbit, the posterior half of the sixth and the anterior half of the seventh with the lower postocular, and the remainder of the seventh, and the eighth and ninth with the temporals. While, however, the first three superior labials are in contact with the nasals a small plate has been cut off from the upper part of each of the fourth, fifth, and sixth plates, which constitute the small scutes usually designated as lower loreal, lower or subpreocular and anterior subocular. In this specimen the sixth supralabial on each side is fused with the lower postocular leaving but two plates in that series. If this were not the case the sixth labial would, as indicated above, be in contact with the orbit and lower postocular. If the posterior half of the upper part of the sixth was also cut off as a small plate (posterior subocular) the labials would be entirely separated from the orbit as Stejneger [1] has found in specimens from southern California.

The dorsal scales are smooth and in 17 rows for the greater part of the length, decreasing to 15 and 13 posteriorly. The gastrosteges are 206 in number, the urosteges 87. The anal plate is divided.

Habitat Relations.— This specimen of *S. hexalepis* was taken on the Greasewood plains to the east of Tucson (on the University campus). This is all that can be said as to its habitat in this region.

Almost nothing is recorded on the habits of the species. The well developed rostral plate seems to indicate that it is more or less of a burrowing form, and Van Denburgh [2] records a specimen from northern Lower California, which was found partly buried in sand. Stejneger [3] states that this snake "to a great extent lives in holes in the ground," and suggests that as there is an apparent correlation between the breaking up of the labials and the greater width of the rostrals in western specimens that both of these

[1] North Amer. Fauna, No. 7, 205.
[2] Proc. Calif. Acad. Sci., Series 2, V, 1006.
[3] North Amer. Fauna, No. 7, 205.

modifications are due to the more arid conditions (or the nature of the soil) in that region. There is little doubt but that a well developed rostral in snakes is often at least associated with the habit of burrowing in the loose soil of arid regions, for it is present in such widely separated forms as *Pituophis, Heterodon, Phyllorhyncus* and *Salvadora,* genera that are both arid region forms and of more or less burrowing habits. On the other hand the breaking up of the labial plates does not appear to be a phenomenon restricted to burrowing types, for it also occurs in *Sistrurus, Agkistrodon,* and several other genera which have a normal rostral and are not burrowing forms. It is true that the formation of suboculars in the last two named genera may be due to a different cause, but, excluding this line of argument, before it can be proven that the formation of subocular plates in *Salvadora* is correlated with its burrowing habits it must be demonstrated either that the trait is advantageous to the snake or that there is a region of stress along the upper margin of the labial plates, during burrowing. It is difficult to see how this trait, which is probably associated with a greater flexibility of the head, can be of advantage to a burrowing form. The reverse would rather be expected. Neither can we conceive how the labial plates can be particularly subject to a stress during burrowing that would lead to their breaking up. Another explanation of the phenomena presents itself, which in the judgment of the writer is more satisfactory, although, owing to our very incomplete knowledge of the habits of these snakes and the factors which influence scutellation, it can be considered only as a suggestion. This is that since in *Salvadora* and *Pituophis* the formation of suboculars is principally confined to the upper part of the supralabials, and since also in the act of seizing and swallowing large prey the sides of the mouth in snakes are spread outward, the hinge line being along the groove formed by the upper margin of the labial plates, it is conceivable that the breaking up of these plates may be associated with the need of greater mobility of the sides of the mouth in handling prey. If this explanation is a true one for these forms, the tendency toward the formation of a row of small plates from the upper part of the supralabials may be considered as a step in the breaking up of the plates of the head, which becomes more pronounced in *Agkistrodon* and *Sistrurus,* and reaches its greatest development in *Crotalus.*

The only observations on the food of this species that seems to be recorded is the statement of Dr. Coues [1] that a lizard (*Cnemidophorus sexlineatus*) was found in the stomach of a specimen from Fort Whipple.

Range.— The exact range of this species is not as yet accurately determined. It is known to occur in the desert regions of southern California

[1] Wheeler's Surv. West of the 100th Merid., V, 620.

and Lower California, and from here eastward across the Proplateau region of southern Nevada and Arizona, being replaced in the eastern part of the latter State or in southwestern New Mexico by *Salvadora grahamiæ*. Whether these forms intergrade in this region or not is still an unsettled question, but it is very probable that they do. It is one of the plains forms of the Proplateau region, which is replaced in the prairie region of central Texas by a nearly related form.

Arizona elegans *Kennicott.*

Arizona elegans Kennicott, U. S. and Mex. Bound. Surv., II, 1859, 18.— Baird, Rept. Pac. R. R. Surv., X (Whipple-Ives Route), 1859, 42.— "Bocourt, Miss. Sci. Mex., Rept., XI, 1888, 676."— Van Denburgh, Occ. Papers Calif. Acad. Sci., V, 1897, 193–195.— Brown, Proc. Acad. Nat. Sci. Phila., 1903, 549, 553.

Pityophis elegans Cope, Bull. U. S. Nat. Museum, I, 1875, 39.— Yarrow, Bull. U. S. Nat. Museum, XXIV, 1883, 16, 108.

Rhinechis elegans Cope, Proc. Amer. Phil. Soc., XXIII, 1866, 284.— Cope, Bull. U. S. Nat. Museum, XXXII, 1887, 72.— Cope, Proc. U. S. Nat. Museum, XIV, 1891, 638.— Cope, Amer. Nat., XXX, 1896, 1014.— Cope, Rept. U. S. Nat. Museum, 1898 (1900), 863–865.— Brown, Proc. Acad. Nat. Sci. Phila., 1901, 52.

Coluber arizonæ "Boulenger, Cat. of Snakes in Brit. Museum, II, 1894, 66."

Locality.— A single specimen (No. 1036) of this snake was presented to the party by Prof. Thornber. It was taken on the plains east of Tucson (near the University of Arizona).

Description of Specimen.— Form rather stout. Head moderately distinct. Tail short. Dorsal scales smooth, formula 27–25–23–21–19. Supralabials 8, infralabials 13–14. Oculars 1–2. Two pairs of genials, the posterior the shorter. Gastrosteges 221. Urosteges 46 pairs. Anal plate entire.

The ground color is faded but the markings are distinct. The dorsal pattern consists of a single median series of transverse blotches with dark edges, which alternate with smaller indistinct lateral spots. Small scattered spots on the first four rows of scales, and a single series of blotches on the tail. On the head there are several dark spots on the parietals and frontal, a cross bar between the eyes along the suture of the frontal and occipitals with the prefrontals, a short bar immediately below the eye, another from the eye to the posterior margin of the last supralabial, and a fourth extending backward from the upper edge of the orbit.

Habitat Relations.— The single specimen obtained was taken in the Creosote bush association on the plains east of Tucson. Professor Thornber informed us that he has taken several specimens in this habitat. Van

Denburgh [1] states that a "captive individual ate a brown-shouldered lizard (*Uta stansburiana*)."

Range.— This species has been taken in southern California, southeastern Arizona, and Mesilla Valley, New Mexico. From our present knowledge of its range it is impossible to determine whether it ranges across the Sonoran Desert, or is a form of the Proplateau which pushes southward in the mountains in southern California.

Pituophis catenifer sayi *Schlegel.*

Coluber sayi Schlegel, Ess. Phys. des Serpentes, 1837, 157, 158.

Churchillia bellonia Baird & Girard, Stansbury's Exped. Gt. Salt Lake, 1852, 350–351.

Pityophis bellona Baird & Girard, Cat. of North Amer. Reptiles, 1853, 66–68. (Part.)— Baird, Rept. Pac. R. R. Surv., X (Whipple-Ives Route), 1859, 42.—Allen, Proc. Bost. Soc. Nat. Hist., XVII, 1874, 69.

Pituophis sayi Cope, Proc. U. S. Nat. Museum, XI, 1888, 398.— Baird & Girard, Cat. North Amer. Reptiles, 1853, 151–152.— Cope, Proc. U. S. Nat. Museum, XI, 1888, 398.— Hay, 17th Ann. Rept. Dept. Geol. and Nat. Resources Ind., 1892, 591.— Bailey, North Amer. Fauna, No. 25, 1905, 47.

Pityophis sayi sayi Cope, Bull. U. S. Nat. Museum, I, 1875, 39.—Yarrow, *ibid.*, XXIV, 1883, 16, 105.— Davis & Rice, Bull. Chicago Acad. Sci., I, 1883, 30.— Cope, Proc. U. S. Nat. Museum, XIV, 1892, 641.— Cope, Proc. Acad. Nat. Sci. Phila., 1892, 335.— Cope, Amer. Nat., XXX, 1896, 1014.— Cope, Rept. U. S. Nat. Museum, 1898 (1900), 870–872.

Pituophis macclellani Baird & Girard, Cat. of North Amer. Reptiles, 1853, 68–69.— Baird & Girard, Marcy's Explor. Red River, 1854, 196–197.

Pituophis catenifer sayi Garman, Mem. Mus. Comp. Zool., VIII, No. 3, 1883, 150–151.— Garman, Bull. Ill. State Lab. Nat. Hist., III, 1892, 286–289.— Taylor, Ann. Rept. Nebr. State Board Agric., 1891, 335–337.— Brown, Proc. Acad. Nat. Sci. Phila., 1901, 55; *ibid.*, 1903, 549.— Branson, Kansas Univ. Sci. Bull., XII, No. 13, 1904, 357–360.

Pituophis mexicanus Duméril & Bibron, Erpétol. Gén., VII, 1854, 236–238.

Pituophis sayi mexicanus Yarrow, Wheeler's Surv. West of 100th Merid., V, 1875, 539–540.

Pituophis sayi bellona Coues & Yarrow, Bull. U. S. Geol. Surv. Terr., IV, 1878, 282–283.— Yarrow, Bull. U. S. Nat. Museum, XXIV, 1883, 16, 106–107. (Part.)— Taylor, Ann. Rept. Nebr. State Board Agric., 1891, 337.— Stone & Rehn, Proc. Acad. Nat. Sci. Phila., 1903, 33.

Locality.— The Bull Snakes referred to this variety were only found at Alamogordo, N. M. The Tucson specimens [2] belong to the following form. It is probably the commonest snake in this region.

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[1] Occ. Papers Calif. Acad. Sci., V, 195.

[2] Although Stone has stated that the Alamogordo specimens collected by Rehn and Viereck, are probably referable to *P. c. bellona* (*deserticola*), and Van Denburgh has listed Tucson specimens as *P. sayi*, a comparison of the specimens obtained by us in these two localities reveals at once that the Alamorgordo specimens are true *sayi* while the Tucson individuals are variety *deserticola* as defined by Stejneger. This gives weight to the opinion expressed by Stejneger that Baird's type of *bellona* belongs to variety *sayi* (North Amer. Fauna, No. 7, 206).

Description of Specimens.— The dorsal scale formulas in the specimens obtained are as follows: 29–31–33–31–29–27–25–23; 29–31–29–27–25–23; 27–29–31–29–27–25–23–21. The first five scale rows are smooth, the others keeled. The cephalic plates are normal in number and arrangement except that there are four prefrontals in three specimens and six in the fourth. The rostral plate is long, narrow and elevated. The supralabials are 8–8 in two specimens, 9–9 in one, 8–9 in a fourth. The infralabials are 12–12 in two specimens, 13–13 in the third, and 12–13 in the fourth. In two of the specimens the fourth supralabial is bounded above by the posterior half of the preocular and the adjacent half of the orbit. In two specimens, however, it is separated from the preocular and nearly entirely from the orbit by a small scale, being in contact with the eye only at its posterior angle. This small plate is the second preocular of some writers and is often present in the genus. That it is not formed by a division of the preoculars is, however, quite evident, since it lies below the usual line of contact of the preoculars and subjacent labial, while a true lower preocular would be formed by a transverse division of this plate above this line. It quite evidently takes its origin from the labial series. The fifth labial is entirely excluded from the orbit by a small plate which is usually considered as a part of the postocular series, but this plate we believe also to be a subocular formed from the apex of the second labial that would normally enter the orbit. From this view point the arrangement of the lateral head plates in our specimens is as follows: 1 preocular, 1 posterior subocular, 3 postoculars; 1 preocular, 1 posterior subocular, 2 postoculars (in two specimens); 1 preocular, 1 posterior subocular, 1 anterior subocular, 3 postoculars. The gastrosteges in the four specimens are 222, 232, 233, 233; the urosteges 52, 58, 59, the tail being broken in the fourth. Anal plate entire.

In these specimens the ground color is yellow, the keels of the scales between the spots dark brown (light orange in the two smaller individuals). There is a dorsal series of large chocolate or dark reddish brown spots, about four scales long, nine or ten wide, and separated by the length of three scales. On either side of this series of blotches and alternating with them is a row of small spots similar in color to those of the dorsal row. These spots are distinct posteriorly, but anteriorly tend to fuse longitudinally into narrow dark bands. Beneath this row are two others, the spots of which are also arranged alternately. All of the spots tend to be black edged, but the borders are seldom well defined except on the tail. On the posterior part of the body there is but one row of spots on either side, while on the tail the dorsal spots are in the form of dark red cross bars which are occasionally bifurcated. The head is dark yellow with a dusky band across the line of contact of the supraoculars and frontals with the preoculars and

prefrontals, and numerous spots behind this bar, that are either black or brown edged with black. The supralabials are margined with black with the exception of the last, the fifth, sixth and seventh with but a small spot. Belly white, or yellowish white with a prominent or indistinct black, dusky or reddish blotch on the ends of every third or fourth scute. On the ventral surface of the tail these blotches are fused transversely and longitudinally along the median line and may be continuous or alternating with the dorsal blotches. Distally the lateral blotches are wanting for a greater or lesser distance leaving only the irregular median band.

Habitat Relations.— This Bull Snake has a very wide range of habitat. At Alamogordo it was found in the Mesquite association on the plains, in the Creosote bush association on the alluvial slope, and in the Piñon-Cedar zone on the mountain slope at an elevation of 6,000 ft. It undoubtedly ranges higher than this, as Mr. Edwin Walters of Alamogordo informed us that he had observed it in the Pine-Spruce forest of the higher elevations. The wide range of habitat of the species, in this locality, is in harmony with its extensive geographic range.

In spite of their large size these snakes are very docile, and while said to be able "to defend themselves against the attacks of an ordinary sized dog," [1] seldom attempt to bite. Those secured made little resistance when picked up with the hands, although several were of large size.

The food consists for the most part of small mammals, although a considerable number of birds are probably also taken. The specimen secured in the Piñon-Cedar association had recently swallowed a young rabbit. This was the only stomach examined, but Taylor [2] states that the stomach contents of Nebraska specimens "show that their food is almost wholly made up of rodents, most notably ground mice, but also including rats, gophers, squirrels, moles and similar animals." Bailey [3] observed one in Texas "in the act of swallowing a freshly killed squirrel (*Citellus m. parvidens*)," and Branson [4] records a specimen in captivity that ate several sparrows and a pigeon's egg. A specimen kept by myself for several months was fed entirely on freshly killed sparrows.

It is rather remarkable that so little is known of the breeding habits of such a conspicuous form as this snake, but I know of but one contribution to our knowledge of the subject. Branson [5] states that he received twelve eggs ("$2\frac{4}{5}$ inches in length by $4\frac{4}{5}$ inches in circumference") on the 15th of August. He describes the embryos as follows: "I opened one of them

[1] Taylor, Ann. Rept. Nebr. State Board of Agric., 1891, 336.
[2] Ann. Rept. Nebr. State Board Agric., 1891, 336.
[3] North Amer. Fauna, No. 25, 47.
[4] Kansas Univ. Sci. Bull., XII, No. 13, 360.
[5] Kansas Univ. Sci. Bull., XII, No. 13, 359.

[the eggs] immediately and found it contained a Bull Snake eight inches long. The snake was surrounded by a gelatinous mass. Its color was olive-buff, with spots faintly outlined in a darker shade. The cephalic plates were well developed. It was able to raise its head about one-third of an inch, but it could not open its mouth. It could see large moving objects. The hemipenis was protruded, and small calcifications were already present on it.

"I placed the other eggs in damp sand where the direct rays of the sun could not reach them. The weather was cool and damp most of the time to the period of their hatching. September 28 two snakes were hatched and during the next three days eight more came out of the eggs. They were fifteen to fifteen and one-half inches long." These snakes are stated to have been very fat when born, and hibernated and emerged the next spring before taking food.

Range.— Pituophis catenifer sayi is a plains and prairie form, being found in the United States from the Rocky Mountains to the western margin of the eastern forest. It is more abundant in Texas, Kansas and Nebraska, but it occurs also in the prairie regions of Iowa and Illinois. To the northward it probably occurs about to the boundary although definite localities are not given in the literature. To the southward it enters the Proplateau region in western Texas and eastern New Mexico and is replaced to the westward by *P. catenifer deserticola.*

Pituophis catenifer sayi Schlegel.

Habitat	Field No.	Locality	When Collected	Collector
		Alamogordo, N. M.		
Creosote bush Assn.	294	Alluvial slope east of Alamogordo	July 15–06	A. G. Ruthven
Piñon-Cedar Assn.	356	West slope of Sacramento Mts. (Alt. 6,000 ft.)	July 17–06	"
Atriplex Assn.	461	Plains three miles east of White Sands	July 19–06	G. von Krockow
Mesquite Assn.	494	Plains southwest of Alamogordo	July 20–06	"

Pituophis catenifer deserticola *Stejneger.*

Pituophis bellona Baird & Girard, Cat. of North Amer. Rept., 1853, 66–68. (Part.)— Kennicott apud Baird, Rept. Pac. R. R. Surv., X (Beckwith-Gunnison Route), 1859, 19.— Kennicott apud Baird, U. S. and Mex. Bound. Surv., II, 1859, 18.— Cope, Proc. Acad. Nat. Sci. Phila., 1866, 305.

Pituophis sayi bellona Cope, Bull. U. S. Nat. Museum, I, 1875, 39.— Yarrow, Wheeler's Surv. West of 100th Merid., V, 1875, 540–541.— Coues, *ibid.*, 617–618.— Streets, Bull. U. S. Nat. Museum, VII, 1877, 40–41.— Yarrow, *ibid.*, XXIV, 1883, 106–107. (Part.)— Cope, Proc. U. S. Nat. Museum, XIV, 1892, 641.— Cope, Amer. Natur., XXX, 1896, 1015.— Cope, Rept. U. S. Nat. Museum, 1898 (1900), 872–876.

Pituophis sayi Van Denburgh, Proc. Calif. Acad. Sci., Ser. 2, VI, 1896, 348.

Pituophis catenifer Cope, Proc. Acad. Nat. Sci. Phila., 1883, 18.— Stejneger, North Amer. Fauna, No. 5, 1891, 110.— Meek, Field Museum of Nat. Hist., Zool. Series, VII, 1906, 15–16.

Pituophis catenifer bellona Garman, Mem. Mus. Comp. Zool., VIII, No. 3, 1883, 151.— Brown, Proc. Acad. Nat. Sci. Phila., 1901, 54.

Pituophis catenifer deserticola Stejneger, North Amer. Fauna, No. 7, 1893, 206–208.— Van Denburgh, Proc. Calif. Acad. Sci., Ser. 2, V, 1895, 149.— Van Denburgh, Occ. Papers Calif. Acad. Sci., V, 1897, 198–199.— Stejneger, Proc. U. S. Nat. Museum, XXV, 1902, 153.

Locality.— Two specimens of this snake were secured at Tucson, Ariz. Van Denburgh has recorded a number of individuals collected in this region (Fort Lowell) as *P. sayi*, but his specimens are undoubtedly to be referred to this variety instead.

Description of Specimens.— Our specimens are very evidently *P. catenifer deserticola* for in both of them the rostral is decidedly wider and flatter than in the eastern form. The scale formula in both specimens is 29–31–33–31–29–27–25; the lateral eight in one and five in the other being smooth. The supralabials are 8–8 and 8–9, the infralabials 12–12 and 13–14, the oculars 1–2 in both. In one specimen there is an anterior and posterior subocular on each side, but in the other there is an anterior and posterior subocular on one side, and only a posterior subocular on the other. (See page 579 for a discussion of these plates.) The gastrosteges are 232 and 238, the urosteges 45 and 55. Anal plate entire.

One specimen shows an interesting anomaly in the labial plates, in that from the upper margin of the two plates that precede the one below the orbit two small plates have been cut off that correspond in shape and relative position to the suboculars. These we believe to represent a more advanced stage in the breaking up of the supralabials than is shown by the presence of the suboculars alone. (See p. 579.)

These specimens are more richly colored than most specimens of *P. c. sayi*. There are the usual three rows of dorsal blotches but those of the second lateral row are not well defined, and those of the lowest row are in the form of short vertical bars. In the smaller specimen the blotches on the anterior two-thirds of the body are light reddish brown, posteriorly they are dark red with darker edgings. Tail crossed by a series of very dark red bars. The scales of the interspaces are pale yellow, with bright

orange keels. Head pale yellow with a dusky bar across the junction of the preoculars and prefrontals with the supraoculars and frontal, and a few brown spots on the top of the head. A few labials slightly margined with dusky. Belly yellowish white, with a row of brown spots on either at intervals of two or three scutes. Ventral surface of tail with a series of pale spots on either side that connect with the dorsal cross bars, but do not fuse mesially to form a black band.

In the larger specimen the colors are somewhat duller as is to be expected. The median dorsal series of blotches are chocolate brown anteriorly, very dark red posteriorly, and all margined with darker. The lateral series of blotches are not at all well defined for most of the length, but become more so posteriorly. Tail with one series of black cross bars. Interspaces anteriorly pale yellow, posteriorly bright orange yellow. Head light brown with a trace of the usual dusky bar across the anterior part of the interorbital area and a few spots on the top of the head. Both supralabial and infralabial plates well margined with black. Belly white with a row of black blotches along either side, the free edges of the scutes also often margined with black. On the tail the urostegeal blotches fuse with the dorsal cross bars and with each other along the median ventral line, except posteriorly where the median ventral band is broken up.

Habitat Relations.— This Bull Snake is a plains form but further than this little is recorded on its habits, although they are probably similar to those of the eastern form. At Tucson it occurs commonly on the Greasewood plains, and is doubtless also to be found on the mountains, as Dr. Stejneger [1] records a specimen that was taken in the Huachuca Mts. at an elevation of 5,300 feet. As in the case of many other snakes in this region, while probably not nocturnal it is seldom seen during the hotter part of the day, being found principally in the morning and evening. The large specimen (No. 1043), which was taken about sun down on August 22, had recently swallowed an adult ground squirrel.

Range.— The range of this snake cannot as yet be definitely determined owing to the fact that it has been frequently confused with *P. c. sayi.* It is a Great Basin form, however, being found between the Rocky and Sierra Nevada Mountains. To the northward it extends into Idaho, but its southern limit in Mexico is unknown. In the extreme southern part of the United States it is found across southern California and Arizona from the western margin of the Mojave Desert to the Proplateau region of southeastern Arizona. As shown above it occurs at Tucson, but east of this point it is undoubtedly soon replaced by *P. c. sayi.*

[1] Proc. U. S. Nat. Mus., XXV, 153.

Gyalopium canum *Cope.*

Gyalopium canum Cope, Proc. Acad. Nat. Sci. Phila., 1860, 243; *ibid.*, 1866, 310.— Coues, Wheeler's Surv. West of the 100th Merid., V, 1875, 624.— Cope, Bull. U. S. Nat. Museum, I, 1875, 36.— Yarrow, *ibid.*, XXIV, 1883, 14, 88.— Cope, Amer. Natur., XXX, 1896, 1014.— Cope, Rept. U. S. Nat. Museum, 1898 (1900), 947–948.

Locality.— A small specimen (No. 123) of this species was found dead on the shore of Lake Walters, at the White Sands, west of Alamogordo, N. M.

Description of Specimen.— Form rather robust; head broad and short, tail short. Total length of the single specimen obtained 155 mm., tail 20 mm. Rostral high, protuberant, and projected backward on the upper surface of the snout, broadly separating the internasals and pushing well in between the prefrontals. Superior surface of rostral concave. Internasals much reduced in size. Nostril situated between two plates, the posterior one small and lying entirely behind the nares, the anterior large, extending from the internasal to the margin of the mouth. No loreal, the prefrontals extending to the posterior nasal and second labial scutes. Supralabials 7, infralabials 7–8. Oculars 1–2. Dorsal scales broad and smooth; formula 19 (for short distance only)–17. Two pair of geneials, the posterior pair very small. Gastrosteges 145, urosteges in 29 pairs. Anal plate divided.

Color above light brownish gray with 49 (40 on body, 9 on tail) transverse, brown blotches with black edges. These spots become narrower on the sides, and persist to the gastrosteges, forming on the anterior and posterior parts of the body a single series of cross bars. On the middle of the body, however, they alternate with a second series of narrow bars extending from the first to the sixth rows. Head olive gray with a broad brown band across the parietals and embracing the apex of the frontal. A second band extends between the eyes across the line of junction of the supraoculars and frontal with the prefrontals; this band is continued below the eye to the margin of the mouth, embracing all of the fourth labial. The four anterior infralabials are margined with darker. Belly white, without markings.

Habitat Relations.— The single specimen of this snake taken was found, as before stated, on the shore of Lake Walters to the east of the White Sands. This makes it evident beyond question that the species occurs in the Atriplex association, as the specimen is immature and was undoubtedly bred in the immediate vicinity. Whether or not it occurs elsewhere is as yet an unsettled question.

Range.— As far as I know but two other specimens of this species have been recorded. One of these is listed simply "Southern Arizona," the

other, the type, came from Fort Buchanan in southeastern Arizona. This, the third specimen, therefore, extends the range of the species across the Proplateau to the East Front Ranges in New Mexico.

Thamnophis eques *Reuss.*

Locality.— Three specimens of this species were taken in the lower part of Sabino Cañon, Santa Catalina Mountains, Ariz., August 18, 1906.

Description of Specimens.— Although one of the more pallid forms this species is one of the most beautiful members of the genus. It has been confused with *T. marciana, T. vagrans,* and *T. parietalis* (*ornata*), but is easily distinguishable. Form rather slender. Lateral stripe on the second and third rows; dorsal stripe narrow, being confined to the median row. Dorsal scale formula 19–17. Cephalic plates normal. Supralabials 8, infralabials 10, oculars 1–3. Gastrosteges 165, 168, 168. Urosteges 78 and 93. Anal plate entire in all specimens.

Color above dark chocolate brown. First row of scales dusky yellow or brownish olive, with a pair of black spots at intervals on the margins of the scales. Lateral stripe pale yellow, the dorsal light orange yellow. Two rows of black spots on the skin between the stripes, encroaching only slightly on the involved scales. Two large black nuchal blotches. No postoral crescent. Head above dark olive in one specimen splashed with black. Supralabials light yellow, except the last one which is light olive, all well margined with black. Belly pale yellow anteriorly, light grayish slate posteriorly; gastrostegeal spots small and mostly concealed beneath the overlapping edge of the preceding scute.

Habitat Relations.— All of the specimens of *T. eques* obtained, were found near the stream in the cañon. Two were lying on rocks in mid stream, the other on the immediate shore. When frightened they immediately took to the water, swimming in the swift current with apparent ease. They doubtless subsist largely upon the frogs and tadpoles which abound in this habitat.

It is gratifying to be able to make these habitat notes, meager as they are, for practically nothing has been heretofore recorded on the habitat relations of this species, and a knowledge of these is essential in the determination of its relationships.

Range.— The range of this species is, as far as known at present, confined to the Mexican plateau and Proplateau. It has been recorded several times from the southern end of the peninsula of Lower California,[1] evidently

[1] Cope, Rept. U. S. Nat. Museum, 1898, 1051. Van Denburgh, Proc. Acad. Nat. Sci. Phila., Ser. 2, V, 151. Cope, Proc. Acad. Nat. Sci. Phila., 1861, 299.

on the basis of a single specimen (No. 5023) in the United States National Museum, said to have been collected by John Xantus. Since, however, there are two specimens of this number in the National Museum, the above and a specimen of *Lichanura*, one being from Fort Buchanan and the other from Cape San Lucas, the garter snake is very probably the Arizona specimen.

Thamnophis marciana *Baird & Girard.*

Locality.— An adult specimen (No. 1029) of this species taken by Prof. Thornber near old Fort Lowell, was presented to the party.

Description of Specimen.— Adult. Cephalic plates normal. Supralabials 8, infralabials 9–10. Oculars 1–3. Dorsal scales keeled with the exception of the first row, formula 21–23–21–19–17. Gastrosteges 157. Anal plate entire.

Color? Three rows of alternating black spots on skin and scales, the lowest being below the lateral stripe which is narrow and occupies the third row only for most of the length, posteriorly including also the second. The dorsal stripe also occupies but one row of scales, the median dorsal. Large nuchal blotches and well defined postoral crescents. Supralabials, with the exception of the sixth, dark olive and well margined with black, the sixth with the postoculars being decidedly lighter. A small black spot on the base of each gastrostege.

Habitat Relations.— The single specimen obtained was secured by Prof. Thornber, in a cultivated field on the bank of Pantano Wash near Old Fort Lowell. These are the only notes obtained on the occurrence of this species, but brief as they are they comprise the first authentic data on the local distribution of the form in Arizona.

Range.— *Thamnophis marciana* ranges throughout central Texas and across the Proplateau region to Tucson. Two specimens in the U. S. National Museum bear the locality of Fort Yuma, but as this is the only record for the desert region of southwestern Arizona it may be held in question until confirmed by other specimens.

Elaps euryxanthus *Kennicott.*

Elaps euryxanthus Kennicott, Proc. Acad. Nat. Sci. Phila., 1860, 337–338.— Cope, *ibid.*, 1861, 296; *ibid.*, 1866, 307.— Cope, Bull. U. S. Nat. Museum, I, 1875, 34.— Coues, Wheeler's Surv. West of 100th Merid., V, 1875, 611.— Streets, Bull. U. S. Nat. Museum, VII, 1877, 40.— Yarrow, *ibid.*, XXIV, 1883, 13, 82. (Part.)— Garman, Mem. Mus. Comp. Zool., VIII, No. 3, 1883, 107, 169.— "Cragin, Bull. Washburn Coll. Labor., I, 1884, 8."— Cope, Bull. U. S. Nat. Museum, XXXII,

1887, 86.— Cope, Proc. U. S. Nat. Museum, XIV, 1892, 681.— Stejneger, Rept. U. S. Nat. Museum, 1893, 362–363.— Cope, Amer. Natur., XXX, 1896, 1014.— Cope, Rept. U. S. Nat. Museum, 1898 (1900), 1125–1126.— Brown, Proc. Acad. Nat. Sci. Phila., 1901, 95.— Stejneger, Proc. U. S. Nat. Museum, XXV, 1902, 157.

Locality.— A specimen (No. 1028) of this Coral Snake was captured by Prof. Thornber near Rosemont, Arizona, and presented by him to the expedition.

Description of Specimen.— Body rather stout; head small and little distinct; tail short and blunt; eyes small. The body is covered above by 15 rows of smooth scales, below by a single row of 227 gastrosteges, and a double series of urosteges consisting of 25 pairs. Anal plate divided. Head plates small except the rostral which is large. Supraorbitals proportionately broad, frontal narrow. Preoculars and posterior nasals broad. No loreal. Seven plates in both the upper and lower labial series. Oculars 1–2, temporals 1–2.

The color is somewhat faded, but the pattern is distinct. It consists of alternating bands of black, white, and bright red, that completely encircle the body. The black and red bands (11 in number between head and anus) are separated from each other by the narrower white rings which are therefore twice as numerous (23 between head and anus). The coloration of the tail consists of a proximal and distal broad black band separated by a narrower one of white. The head is entirely black with the exception of the tips of the parietals and a part of the posterior labials (instead of entirely including the last labial) [1] which lie within the following white band.

Habitat Relations.— The habits of this species are unknown. I have known persons in Arizona who have handled this snake repeatedly, and who scoff at the idea of its being venomous. It is true that the experiments that have proven the toxicity of the bite of the Coral Snakes have been confined to the eastern species, *E. fulvius*, but as *E. euryxanthus* also possesses well developed fangs, there is no reason to believe that it is any less venomous than the eastern form. That it enjoys the reputation it does is probably due, as in *E. fulvius*, to its amiable disposition and the fact that it is easily confused with some of the harmless snakes.[2] Dr. Stejneger writes of the genus as follows: "It is granted that *Elaps* is comparatively rare; that it is retiring in its habits, mostly living under ground, and that it has a very gentle and amiable temperament. When it does bite, however, its bite is as venomous as that of a rattlesnake or moccasin of the same size, and even more so." [3]

[1] Kennicott, Proc. Acad. Nat. Sci. Phila., 1860, 337.

[2] The resemblance that exists between some of the harmless snakes and the *Elaps* of the same region has been frequently commented upon. Stejneger (Rept. U. S. Nat. Mus., 1893, 356–358) has described how the forms in the United States may be readily distinguished.

[3] Rept. U. S. Nat. Museum, 1893, 355.

Range.— So few specimens of *E. euryxanthus* have been taken that its distribution cannot as yet be determined. Stejneger defines its known range as follows: "It belongs to the Lower Sonoran province, but seems restricted to the regions east of the great Colorado River and west of the Continental divide. It has been found as far north as Fort Whipple and at various places in southern Arizona, extending south into Mexico at least as far south as Batopilas, in the state of Chihuahua, in the interior, and to Guaymas, Sonora, on the Gulf of California. In Arizona it reaches an altitude above the sea of at least 5,000 feet." [1]

Crotalus atrox *Baird & Girard.*

Crotalus atrox Baird & Girard, Cat. of North Amer. Reptiles, 1853, 5–6, 156.— Duméril & Bibron, Erpétologie Générale, VII, Pt. 2, 1854, 1482.— Hallowell, Proc. Acad. Nat. Sci. Phila., 1856, 307.— Baird, U. S. and Mex. Bound. Surv., II, 1859, 14.— Baird, Rept. Pac. R. R. Surv., X (Whipple-Ives Route), 1859, 39.— Cope, Proc. Acad. Nat. Sci. Phila., 1859, 337.— Cooper, Proc. Calif. Acad. Sci., IV, 1870, 66.— Cope apud Yarrow, Wheeler's Surv. West of 100th Merid., V, 1875, 534.— Stejneger, Rept. U. S. Nat. Museum, 1893, 436–439.— Van Denburgh, Proc. Calif. Acad. Sci., Ser. 2, V, 1895, 156–157.— Van Denburgh, *ibid.*, Ser. 2, VI, 1896, 348.— Stejneger, Proc. U. S. Nat. Museum, XXV, 1902, 158.— Bailey, North Amer. Fauna, No. 25, 1905, 49–50.— Ditmars, The World Today, Oct., 1906, 1049.

Caudisona atrox "Cope apud Mitchell's Researches ven. Rattle., 1861, 121." — Cope, Proc. Acad. Nat. Sci., Phila., 1866, 309, 310, 311.

Crotalus atrox atrox Brown, Proc. Acad. Nat. Sci. Phila., 1901, 103–104; *ibid.*, 1903, 551, 553.

Crotalus adamanteus atrox "Jan. Rev. Mag. Zool., 1859, 28."—Jan. Elenc. Sist. Ofid., 1863, 123.— Cope, Bull. U. S. Nat. Museum, I, 1875, 33.— Streets, *ibid.*, VII, 1877, 40, 41.— Cope, *ibid.*, XVII, 1880, 24.— Yarrow, *ibid.*, XXIV, 1883, 12, 75–76.— Garman, Mem. Mus. Comp. Zool., VIII, No. 3, 1883, 113, 172.— Cope, Proc. Amer. Phil. Soc., 1885, 287.— Cope, Bull. U. S. Nat. Museum, XXXII, 1887, 90.— Cope, Proc. U. S. Nat. Museum, XI, 1888, 398.— Cope, *ibid.*, XII, 1889, 147.— Cope, *ibid.*, XIV, 1892, 690.—Cope, Proc. Acad. Nat. Sci. Phila., 1892, 366.— Cope, Amer. Natur., XXX, 1896, 1013.— Cope, Rept. U. S. Nat. Museum, 1898 (1900), 1164–1167.— Stone & Rehn, Proc. Acad. Nat. Sci. Phila., 1903, 33.

Caudisona adamanteus atrox Coues, Wheeler's Surv. West of 100th Merid., V, 1875, 607.

Caudisona atrox sonorœnsis Kennicott, Proc. Acad. Nat. Sci. Phila., 1861, 207.— Cope, *ibid.*, 1861, 292.

Crotalus adamanteus sonoriensis Jan, Elenc. Sist. Ofid., 1863, 124.

Caudisona scutulata Kennicott, Proc. Acad. Nat. Sci. Phila., 1861, 207–208.— Cope, *ibid.*, 1866, 307.

Crotalus scutulatus Cope apud Yarrow, Wheeler's Surv. West of 100th Merid., V, 1875, 533.

[1] Rept. U. S. Nat. Museum, 1893, 356.

Crotalus adamanteus scutulatus COPE, Bull. U. S. Nat. Museum, I, 1875, 33.— YARROW, *ibid.*, XXIV, 1883, 12, 76.— COPE, Proc. Amer. Phil. Soc., 1885, 287. — COPE, Proc. U. S. Nat. Museum, XIV, 1892, 690.

Caudisona adamantea scutulata COUES, Wheeler's Surv. West of 100th Merid., V, 1875, 607–608.

Crotalus adamanteus "JAN, Icon. Ophid., 1874, livr. 46, Pl. II, fig. 1."

Locality.— Five specimens of this rattlesnake were taken in the vicinity of Tucson, Ariz. Not found at Alamogordo, N. M., although it occurs there.[1]

Description of Specimens.— The specimens obtained range in length from 606 to 1026 mm. Head flat. Orbit depressed, surrounded below and behind by a single series of small plates which are separated from the reduced supralabials by three rows of scales. Two preoculars, the inferior bordered in front by the pit, the superior by the loreal and the lower end of a cephalic scute. Two nasals, the nostril situated in the posterior, the anterior in contact with the rostral. A group of small scales occupies the triangular space in front of the pit, between the nasal, rostral and supralabial scutes. Rostral narrow. Supralabials 14–15, infralabials 15–18.

The cephalic plates are variable. In all of the specimens there is a pair of small plates immediately behind the rostral. From the external side of these plates an elongated scute extends backward along the superior margin of the anterior and posterior nasals, the line of contact being along the canthus rostralis. Posterior to this plate is a second enlarged scute which is in contact posteriorly with the supraocular and bends over the canthus rostralis to meet the upper preocular and loreal. The supraoculars are large and margined on the inner side by a single series of small plates. The scutellation of the muzzle within the marginal scales just described varies in the different specimens. In one individual the space is occupied by small scales irregularly disposed. In another the first pair of interorbital scutes are a little enlarged, and each one is preceded by a similar enlarged plate, both pairs being separated by smaller paired scutes in line with the internasals. In a third the first pair of interorbitals are enlarged and in contact, but the preceding pair of scutes are separated by small scales. In the fourth the pair of scutes preceding the first pair of interorbital plates, which are in contact, are separated only by two narrow scutes, while in the fifth they are in contact, and the scutellation of the upper surface of the muzzle consists of four pairs of rather large scutes, extending from the rostral to between the eyes. Thus there seems to be revealed in these specimens a tendency toward the fusion of the cephalic plates.

The body is robust and the tail short. The dorsal scales are keeled

[1] Stone and Rehn, Proc. Acad. Nat. Sci. Phila., 1903, 33.

with the exception of the outer two which are smooth. The arrangement is 25–23–21–19 in two, but in the others there is an increased number on the neck, where the scales are much smaller than elsewhere on the body. The gastrosteges vary in number from 175–186. The urosteges range from 18–26 and are mostly entire with the exception of the distal 1–5. Anal plate single.

The color is strikingly pallid. In four specimens the ground color is light brownish or yellowish ash. The dorsal rhombs are light brown or dark ash, the centers being lighter, and they are margined with pale yellow. The anterior and posterior angles of these rhombs are nearly always truncate, those on the anterior part of the body often notched. On the posterior part of the body the dorsal blotches are compressed into cross bands that on the tail form 3–5 black cross bars. In these specimens there is evidence of two rows of dusky blotches on the body below the dorsal rhombs, but these are very faint. Head above about the same as the ground color of the dorsal surface of the body. End of muzzle to the first facial stripe about the same. The facial stripes are light yellow. The first includes the preoculars and runs downward and backward to embrace all of the supralabials posterior to the seventh. The second is narrower and extends from the posterior angle of the supraoculars to the angle of the mouth. Between the facial stripes, and extending from the eye to the angle of the mouth is a dusky band about two and one-half to four scales wide. Belly yellowish white, immaculate.

In a large old male the ground color posteriorly is dull orange red becoming dove gray tinged with pink anteriorly, the entire upper surface being marked with fine black spots. The rhombs are dark reddish brown, lighter toward the center, and with light margins. The tail bars are jet black, the interspaces pale yellow.

Habitat Relations.— I find nothing recorded on the habits of this rattlesnake. About Tucson it is common both on the plains and slopes. Individuals are, however, seldom observed during the heat of the day, except after heavy rains or on cloudy or foggy days, when they are more abundant. Mr. F. E. Lloyd informed us that he has, when sleeping on the ground, been awakened in the night by a snake of this species crawling over his blankets, which with the vertical pupil indicates nocturnal habits.

The partially digested remains of a full grown ground squirrel was removed from the stomach of a specimen which I discovered one morning under a Crucifixion thorn bush. In the stomach of another a stone was found which measured 14 mm. in diameter. Since this snake measured but 760 mm. in length the stone is too large to have been contained in the crop

of any bird which it could swallow, and it was probably picked up accidentally in seizing or swallowing food.

Range.—This is one of the few forms secured by the expedition, that ranges from the low deserts of southern California and southwestern Arizona across the Proplateau region into New Mexico and Texas. In Texas it occupies the territory lying between the ninety-seventh meridian and the Staked Plains, south of the Canadian River. It ranges up the Pecos Valley at least as far as Santa Rosa, through the Trans-Pecos region, and to some extent up the Hueco bolson and Rio Grande Valleys.

Crotalus atrox Baird & Girard.

Habitat	Field No.	Locality	When Collected	Collector
		Alamogordo, N. M.		
Creosote bush Assn.	761	Plains south of Tucson	Aug. 8–06	G. von Krockow
"	1002	Plains east of Tucson	Aug. 20–06	"
"	1015	Mesa west of Santa Cruz River	Aug. 21–06	A. G. Ruthven
"	909	Plains east of Tucson	Aug. 15–06	G. von Krockow
"	1045	Mesa west of Santa Cruz River	Aug. 24–06	F. E. Lloyd.

TESTUDINES.

Kinosternon sonoriense *Le Conte.*

Kinosternon sonoriense Le Conte, Proc. Acad. Nat. Sci. Phila., 1854, 184.— Coues, Wheeler's Surv. West of 100th Merid., V, 1875, 589.— Cope, Bull. U. S. Nat. Museum, I, 1875, 52.— Yarrow, *ibid.*, XXIV, 1883, 6, 31.— Stejneger, Proc. U. S. Nat. Museum, XXV, 1902, 149.

Thyrosternum sonoriense Agassiz, Contrib. Nat. Hist. U. S., I, 1857, 428.— Baird, U. S. and Mex. Bound. Surv., II, 1859, 3.

Locality.— A single specimen (No. 988) of this turtle was taken in the lower part of Sabino Cañon, Santa Catalina Mountains, Ariz.

Description of Specimen.— Plastron rather large nearly closing the shell. Carapace rather strongly convex, wider and sloping steeply posteriorly, converging gradually both dorsally and laterally toward the anterior end. Three dorsal keels, the median along the vertebrals, the lateral along the upper part of the costal scutes. Nuchal plate rectangular. Marginals 22. Costals 8. Vertebrals 5. Plastron broadly rounded in front, emarginate behind. Skin of throat and sides of neck roughly tubercular, becoming smooth on the nape. Both on the dorsal and ventral surface of the neck

there are small scattered papillæ and a well defined row of larger ones in line with the upper margin of ear; another less well defined row extends backward beneath the lower jaw. In the latter row there are two pairs of more prominent ones situated respectively near the symphysis of the lower jaw and angle of the mouth. Several poorly defined rows of small tubercles on the tail, and a fringe of them about the anus. Tail terminating in a strong nail. Three large scales on the forearm, and three near the heel. Tail strongly sulcate beneath.

Carapace dull reddish brown, plastron dull yellow, all scutes faintly but broadly margined with black. Skin of upper surfaces black. Head above mottled with dull reddish brown and black. Beak light horn color splashed with black. Throat densely spotted with pale yellow and black. Under surface of limbs blackish brown.

Length of carapace 112.5 mm.; width of carapace between fifth marginals 70.5 mm., between eighth marginals 73. Greatest width of plastron (across anterior part of abdominals) 56 mm. Length of plastron 100.6 mm.

Habitat Relations.— Little is recorded on the habits of this species. Stejneger records it as occurring in cañons in the Huachuca Mountains. Our specimen was found on a stone in the stream in Sabino Cañon.

Range.— The only three localities previously recorded for the species are Tucson, Huachuca Mountains, and Guadulupe Cañon, all in southeastern Arizona.

Terrapene ornata *Agassiz.*

Cistudo ornata Agassiz, Contrib. Natur. Hist. U. S., I, 1857, 445.— Cope, Bull. U. S. Nat. Museum, I, 1875, 53.— Coues & Yarrow, Bull. U. S. Geol. Surv. Terr., IV, 1878, 260.— Cope, Bull. U. S. Nat. Museum, XVII, 1880, 13.— Yarrow, *ibid.*, XXIV, 1883, 7, 37.— "Garman, Bull. Essex Inst., XVI, 1884."— Cope, Proc. U. S. Nat. Museum, XI, 1888, 397.— " Boulenger, Cat. Chelonians Brit. Mus., 1889, 118."— Garman, Bull. Ill. State Lab. Nat. Hist., III, 1892, 220–221.— Hay, 17th Ann. Rept. Ind. Geol. and Nat. Hist. Surv., 1892, 595.— Cope, Proc. Acad. Nat. Sci. Phila., 1892, 333.

Terrapene ornata Baur, Science, N. S., XVII, 1891, 190.— Baur, Am. Natur., XXVII, 1893, 678.— Taylor, Proc. U. S. Nat. Museum, XVII, 1895, 573–588.— Van Denburgh, Proc. Calif. Acad. Sci., Ser. 2, VI, 1896, 338.— Jordan, Manual of Vertebrates of North. U. S., 8th ed., 1899, 211.— Brown, Proc. Acad. Nat. Sci. Phila., 1903, 544, 553.

Locality.— Three live specimens and a part of the shell of a fourth individual of this species were taken on the plain near Alamogordo. The residents state that it is not abundant and is only occasionally seen. Van Denburgh has recorded a specimen from the vicinity of Tucson, but we failed to find it in that region.

Description of Specimens.— The specimens obtained agree closely with Taylor's diagnosis and their description may be summarized as follows: Quadrato-jugal absent. Claws on fore-feet 5, on hind feet 4. Digits without distinct web. Phalanges in fore foot 2 in each digit. Carapace flattened above making it broadly oval in cross section. A median ridge is present but no keel, and the third vertebral plate is less than two-thirds as long as wide. Plastron widest across abdominal plates.

In all of the specimens the head is light brown above, with small spots of greenish gray; the throat is grayish yellow, and the neck above a dark gray. Likewise in all three specimens the skin on the body and legs is a uniform dull gray, and the large scales on the fore-legs have light yellow centers and dark brown borders.

In No. 462 the ground color above is light chocolate brown marked with small irregular greenish yellow maculations. These markings are rather indistinct, form no distinct pattern, and become quite obscure on the last two costal and sixth vertebral scutes. The plastron is a dull yellow with large dull brown blotches.

In No. 827 the ground color of the carapace is dark chocolate brown with distinct markings of dull greenish yellow, in the form of narrow bands which exhibit a tendency to radiate from the growth centers of the scutes and to form a median dorsal line. The plastron is dark chocolate brown with very numerous irregular bands of dull greenish yellow.

In No. 828 the ground color of the carapace is blackish relieved by numerous distinct greenish yellow bands that show a pronounced tendency to radiate from the growth centers, and form a nearly continuous vertebral line along the dorsal ridge. The ground color of the plastron is the same as that of the carapace, with numerous irregular bands of dull greenish yellow.

Habitat Relations.— These specimens were all taken on the plains in the Mesquite and Atriplex associations. It was not observed above the plains and, while this is in no way indicative that it does not occur on the mountain slopes, it is doubtful if it does so, as the stony nature of the ground would seem to be unfavorable to its burrowing habits. It was only observed after rains.

Range.— This Box Tortoise inhabits the more arid parts of the United States. Its home may be defined as the Great Plains and Prairie regions of central United States, and the arid plains of the Proplateau, but the limits of its range are yet to be drawn. Taylor [1] gave it in 1895 as occurring "from the Rocky Mountains east to Lake Michigan and Indiana, south to the Ozark

[1] Proc. U. S. Nat. Museum, XVII, 582–583.

Mountains, and east to western Indian Territory and central Texas, and from the Rio Grande River north to the Yellowstone River." Since then, however, Van Denburgh [1] has recorded a specimen from near Fort Lowell (Tucson, Ariz.), which extends the range considerably further to the westward. Taylor notes the fact that no species of *Terrapene* has been reported west of the Rocky Mountains, and suggests that this may be due to the "great elevation and consequent climate of the mountains." This explanation is probably the true one on the Great Plains, for being an arid type the increased moisture that characterizes the slopes of the Rockies, as well as the increased altitude and lower temperatures, probably serve to limit its habitat on the west. In the Proplateau region, however, this barrier does not exist, as the arid basins form a highway by which plains types may push into the southern parts of New Mexico and Arizona. That the Western Box Tortoise takes advantage of this highway is shown by the following locality records: San Antonio to Fort Inge, Texas (Taylor); Alamogordo and Las Cruces, N. M., and El Paso, Texas (Taylor); Fort Lowell, Arizona (Van Denburgh).

Terrapene ornata Agassiz.

Habitat	Field No	Locality	When Collected	Collector
		Alamogordo, N. M.		
Mesquite Assn.	178	Plains south of Alamogordo	July 11–06	G. von Krockow
"	327	Plains west of Alamogordo	July 16–06	"
"	328	"	"	"
Atriplex Assn.	462	"	July 19–06	A. F. Zimmer

Summary and Conclusions.

In the following table the local distribution of the different species of reptiles [2] taken at Alamogordo, N. M., and Tucson, Ariz. has been summarized.

[1] Proc. Calif. Acad. Sci., Ser. 2, VI, 338.

[2] The data on the habitat distribution of the amphibians of this region is entirely too small to permit of any generalizations at present.

Habitat Distribution of the Reptiles taken at Alamogordo, New Mexico, and Tucson, Arizona.

ALAMOGORDO, NEW MEXICO			TUCSON, ARIZONA		
Fauna	Habitat	Species	Species	Habitat	Fauna
Summit Type	Mountain slopes between 7000 and 10,000 ft. (Pine-Spruce Assn.)	Phrynosoma hernandesi	(?)	Mountain summits (Pine-Spruce Assn.)	Summit Type
Plateau Type	Mountain slopes between 5500 and 7,000 ft. (Piñon-Cedar Assn.)	(Uta ornata) Sceloporus consobrinus (Phrynosoma hernandesi) Pituophis catenifer sayi	(Uta ornata) (Sceloporus consobrinus) (Phrynosoma hernandesi)	Higher Mountain slopes (Piñon-Cedar Assn.)	Plateau Type
	Wet cañons below 5500 feet	(?)	Kinosternon sonoriense Cnemidophorus gularis Uta ornata Holbrookia maculata approximans Thamnophis eques Sceloporus clarkii	Wet cañons below 6,000 feet (Willow-Poplar Assn.)	
			Sceloporus clarkii Uta ornata Cnemidophorus gularis	River banks on plains (Willow-Poplar Assn.)	
	Mountain slopes below 5,500 ft. (Sotol-Ocotillo Assn.)	(Uta stansburiana) Crotaphytus collaris baileyi (Sceloporus consobrinus) (Pituophis catenifer sayi)	Uta stansburiana Bascanion piceum Heloderma suspectum Cnemidophorus melanostethus	Alluvial slopes, hills (Suaharo-Ocotillo Assn.)	
			Cnemidophorus melanostethus Crotalus atrox Uta stansburiana	Alluvial slopes, arroyos (Acacia Assn.)	
	Dry cañons below 5,500 ft. (Sotol-Ocotillo Assn.)	Cnemidophorus gularis (Holbrookia texana)	Callisaurus ventralis Holbrookia maculata approximans	Alluvial slopes (Creosote bush Assn.)	

Arid Plains Type					
Alluvial slopes (Creosote-bush Assn.)	Chemidophorus melanostethus Uta stansburiana Sceloporus magister Crotaphytus wislizenii Pituophis catenifer sayi Phrynosoma cornutum Anota modesta Sceloporus consobrinus	Chemidophorus melanostethus Uta stansburiana Sceloporus magister Crotaphytus wislizenii Pituophis catenifer deserticola Arizona elegans Phrynosoma solare Bascanion flagellum frenatum Salvadora hexalepis Arizona elegans Crotalus atrox	Plains (Creosote bush Assn.)	Arid Plains Type	
Alluvial slope arroyos (Sotol-Ocotillo Assn.)	Chemidophorus gularis	Callisaurus ventralis Holbrookia maculata approximans	Washes on the plains (Acacia Assn.)		
Margin of plains (Mesquite Assn.)	Chemidophorus sexlineatus Anota modesta Phrynosoma cornutum Pituophis catenifer sayi Sceloporus consobrinus Uta stansburiana	(?)	Near streams on plains (Mesquite Assn.)		
Central depression (Atriplex Assn.)	Chemidophorus sexlineatus Crotaphytus collaris baileyi Phrynosoma cornutum Anota modesta Sceloporus consobrinus Uta stansburiana Gyalopium canum	Chemidophorus melanostethus Callisaurus ventralis	Salt spots (Atriplex Assn.)		
White Sands Sumac-Yucca Assn.)	Sceloporus consobrinus (observed on first dunes only) Chemidophorus sexlineatus Holbrookia maculata flavilenta				

From the data in the annotated list, as summarized in the above table, it may be noted:

1. *That each set of environmental conditions which is marked out by a distinct plant association has a definite reptile fauna.*

2. *That the reptile fauna of the Pine-Spruce and Piñon-Cedar association is (considered together) composed of but few species, some of which are partly arboreal in habits.* As the reptiles are a tropical group this is the condition of affairs that we should expect since the environmental conditions in these associations, so far as they affect the reptile life, may be summarized as follows: cold winters and cool summers, greater precipitation, abundant arboreal vegetation.

3. *That the reptile fauna which inhabits the wooded riparian habitat on the plains is very similar to that of the Pine-Spruce and Piñon-Cedar associations.* This is also what we might expect from the similarity in the conditions and the continuity that exists between these two habitats.

4. *That the biota of the terrestrial habitats below the Piñon-Cedar association, with the exception of the riparian habitats, are more nearly related to each other than to those above them, and may be considered as belonging to a single type — that of the Arid plains.* This is shown by the fact that very few of the forms found below the Piñon-Cedar zone are peculiar to a single association, most of them occurring in two or more habitats, while but few occur also in the Piñon-Cedar association or above.

This may be attributed to the fact that the environmental conditions within this area differ gradually and only in a limited degree, so that the biota of the different habitats do not become strikingly different, the effect of the change in the conditions being shown principally by a difference in the relative abundance of the species. The conditions of all the subhabitats are very arid and the vegetation low and scanty, so that the reptile faunas of the different associations must conform to the same general conditions. That they do so is shown by the fact that they all possess the following characteristics: (*a*) they require a minimum amount of water, (*b*) they are all ground forms, and those which do not rely for protection upon their powers of defense depend upon their powers of locomotion, the protection of holes or a protective resemblance to the soil, (*c*) their food consists primarily of ground-forms such as ants, grasshoppers, small mammals, other reptiles, etc.

5. *That the affinities of the biota of the Pine-Spruce and Piñon-Cedar associations are with the Rocky and Sierra Nevada Mountains.* These associations are confined in the Proplateau region to the higher elevations but to the northward spread over the High Plateau. This is well illustrated by the range of three of the characteristic forms.

(*a*) *Juniperus monosperma.* "Along the eastern base of the Rocky

Mountains from the divide between the Platte and Arkansas rivers in Colorado to western Texas, spreading over the Colorado plateau, over the mountain ranges of Nevada, southern New Mexico and Arizona, and southward into northern Mexico; often covering with the Nut Pine, in southern Colorado and Utah and in northern and central New Mexico and Arizona, great areas of rolling hills 6,000° to 7,000° above the sea level; reaching its largest size in northern Arizona." (Sargent, Manual of the Trees of N. A., 93).

(*b*) *Pinus ponderosa.* "The form of the Rocky Mountains (var. *scopulorum,* Engelm.), ranging from Nebraska to Texas and over the mountain ranges of Wyoming, eastern Montana and Colorado, and to northern New Mexico and Arizona, where it forms on the Colorado plateau the most extensive Pine forests of the continent." (Sargent, Manual of the Trees of N. A., 16).

(*c*) *Phrynosoma hernandesi.* "The wooded plateau region of Colorado, Utah, New Mexico, and Arizona." (Stejneger, North Amer. Fauna, No. 3, 113).

6. *That most of the reptiles of the Arid plains are characteristic of the Proplateau region and Mexican Plateau, but the fauna shares several forms with central Texas on the east and the Sonoran Desert on the west, and in return receives at its margins several species from these regions.* For example, *Cnemidophorus melanostethus, Holbrookia approximans* and *Sceloporus magister* may be considered peculiar to the Proplateau region, while *Cnemidophorus sexlineatus* enters its borders on the east from the Prairie region of Central Texas, and *Callisaurus ventralis, Phrynosoma solare* and *Heloderma suspectum* on the west from the Sonoran Desert.

7. *That several of the Arid plains forms which occur also in central Texas show a tendency to become differentiated from their eastern representatives in southern New Mexico and western Texas.* The better known examples of this have been discovered by Stejneger. They are *Pituophis catenifer deserticola* and *P. catenifer sayi, Coleonyx variegatus* and *C. brevis, Crotaphytus collaris* and *C. collaris baileyi.*

Corresponding, therefore, with the different sets of environmental conditions previously pointed out (the Mountain summit, Plateau and Arid plains habitats), there are three distinct biota in the Proplateau region. Merriam [1] in his map of the life zones of North America does not recognize the Arid plains habitat in southeastern Arizona and southwestern New Mexico, but in eastern New Mexico has defined our three major habitats as Transition (Mountain Summit), Upper Sonoran (Plateau) and Lower Sonoran (Arid plains) zones, and his application of the two former terms

[1] Year book Dept. of Agriculture, 1894.

has been followed by later writers. Cockerell,[1] however, has pointed out that the Arid plains biota is to be distinguished from the rest of Merriam's Lower Sonoran zone (which included central Texas and southwestern Arizona), and has suggested the name of Middle Sonoran for this habitat, which he held to be a part of the Upper Sonoran zone. Bailey,[2] however, while recognizing the difference between the biota of the Arid plains of the Trans-Pecos region and that of the Prairie region of central Texas, places the former as a subdivision (extreme arid Lower Sonoran) of the Lower Sonoran, thus recognizing that its affinities are with the Prairie region of central Texas rather than with those of the Piñon-Cedar association, which is obviously the case. Furthermore, although Merriam includes this habitat with the low plains of southwestern Arizona in his lower Sonoran zone, it must be recognized that, at least from the standpoint of the reptile life, these two regions are quite as distinct as are the Arid plains of the Proplateau and the Prairie region of central Texas. It is a broad generalization to class these three regions together in one "zone."

On the whole, it seems advisable at the present time, at least from the standpoint of reptiles, not to attempt to stretch any one "zone" over the entire continent, but rather to express the relationships of the biota of the different regions studied, in provincial terms. Until more data shall have been accumulated such wide generalizations serve to obscure the finer details of habitat distribution.

The present distribution of the reptiles of this region has been described above as if the present conditions were stable. They are far from being so, however. The mountains are being rapidly denuded, and the habitat of the Pine-Spruce and Piñon-Cedar associations consequently destroyed. The higher intermontane basins (of the type of the Hueco bolson) are being filled up, as the mountains are lowered, and will in time obtain streams of their own by the headward erosion of the streams in lower and adjoining basins. When this has taken place the Mesquite association will become confined principally to the stream margins, the Creosote bush association will move down upon the plains, and the Atriplex association will become restricted to local areas, a stage which is represented at Tucson at the present time. The arid plains forms thus tend to become the climax type. Davis [3] has characterized the advanced stage in the geographical cycle as follows: "the initial relief will be extinguished even under the slow processes of desert erosion, and there will appear instead large, rock-floored plains sloping toward large waste-floored plains; the plains will be interrupted only where

[1] New Mex. Agric. Exp. Sta., Bull. 15, 24, 28. Amer. Natur., XXXIV, 285–293.
[2] North Amer., Fauna, No. 25.
[3] Jour. of Geology, XIII, 388.

parts of the initial highlands and masses of unusually resistant rocks here and there survive as isolated residual mountains." We should expect, therefore, that as the aridity increased the forms in the more arid regions adjoining (southwestern Arizona) would push in, possibly to the exclusion of the present forms.

Far too little is known of the geological history of this region to permit of the application of this order of succession to the solution of the problem of the origin of the different biota at present found in the Proplateau region. Since, however, the characteristic forms of the Arid plains, Piñon-Cedar and Pine-Spruce associations belong to genera which have their greatest development on the plains in this region it seems safe to adopt the conclusion, at least as a working hypothesis, that the reptiles of the Arid plains have had their origin in this general region (Mexican plateau and Proplateau), and that the forms of the Piñon-Cedar and Pine-Spruce associations have been derived from them.

56.52(78.8)

Article XXIV.— SOME FOSSIL ARTHROPODS FROM FLORISSANT, COLORADO.

By T. D. A. Cockerell.

MYRIAPODA.

Julidæ.

Iulus florissantellus sp. nov.

Body rings about 41 or 42, longitudinally striate below the middle, the striæ coarse and not numerous, the upper ones about 170 μ apart, the lower about 85. Depth of body near middle about 1275 μ; length of a middle segment dorsally about 680; length of legs at middle of body about 1190; caudal end pointed. The specimen is curled up, and in this position has a diameter of 7¼ mm. Station 14 (*W. M. Wheeler*). (Fig. 1.)

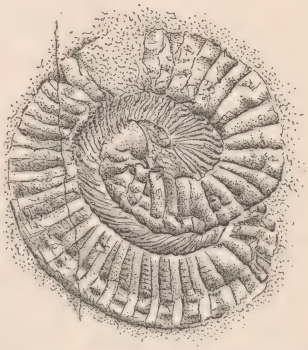


Fig. 1. *Iulus florissantellus* sp. nov.

This is the only Myriapod yet found at Florissant.

ARACHNIDA.

Phalangiidæ.

Leptobunus atavus sp. nov.

Similar to the modern *L. grandis* (Say). Body of the usual shape, about 7 mm. long, dorsally pallid, the posterior half with a broad dark lateral stripe, tapering at either end; this stripe is about 3½ mm. long. Palpi normal; last joint more slender than penultimate one, and obviously longer; the last two joints together measure about 2⅓ mm. Three legs are preserved, apparently the first pair and one of the second ones. Anterior (?) femur about 8 mm., their tibiæ 6 mm.; their tarsi 11. Second (?) femur 7 mm., tibia 4½, tarsus 9⅓. Some doubt is cast on the identification of these legs as belonging to the first and second pairs, owing to their relative measurements; the first should be shorter. (Fig. 2.)

Fig. 2. *Leptobunus atavus* sp. nov.

One good specimen, with reverse; Station 14 (*W. P. Cockerell*). This is the first harvest-spider from Florissant.

Leptobunus Banks is part of *Liobunum*, as formerly understood. The antiquity of the group, as here indicated, favors the segregation.

NEUROPTERA.

Raphidiidæ.

Megaraphidia gen. nov.

Anterior wing, compared with the same wing of *Raphidia oblita*, as figured by McClendon in 'Entomological News,' April, 1906, p. 117, shows the following resemblances and differences:—

Costal region, subcosta and pterostigma all normal.

R^1 with two branches beyond pterostigma (one in *Raphidia*).

Cross-vein from R^1 to R^2 before stigma normal.

Second cross-vein arising from near beginning of apical fifth of pterostigma (beyond it in *Raphidia*), and R^1 not at all bowed at its origin. It enters R^2 at point of origin of last branch of that nervure.

R^2 with five branches (three in *Raphidia*), of which all but the third fork near end, the forks normal in form.

R^3 arising beyond the first cross-vein (instead of before it) — about as far beyond as length of cross-vein — and ending in a very long fork, longer than its stem (a very short fork in *Raphidia*).

No cross-vein from R^3 to R^2; but a cross-vein to R^{4+5}, as in *Raphidia*, this cross-vein however near to origin of R^3, not far from it as in *Raphidia*.

R^{4+5} separating into a long fork, as long as that of R^3, its lower branch having a short apical fork.

A cross-vein to M just beyond cross-vein between R^3 and R^{4+5} (before it in *Raphidia*).

From position of R^3, and the absence of a cross-vein between R^3 and R^2, it results that there is a single large pentagonal cell in the forks of R^2 and RS.

Radius, media and Cu^1 separating normally, at a single point.

Media with four apical forks in succession from the first (three in *Raphidia*); the stem of the third arises normally from a cross-vein.

Last fork of media very small (large in *Raphidia*).

Cu^1 and Cu^2 normal.

Anal veins normal basally, but meeting at a point (not approaching, and joined by a cross-vein), so as to make an X, and the apical vein not forked.

Many of the above characters are very likely not even of specific value, but several of them are so distinctive as to quite alter the appearance of the wing, and the combination appears to justify a new generic name.

Megaraphidia elegans sp. nov.

Represented by a single anterior wing, perfectly hyaline, with very distinct nervures, its length about 14 mm., or slightly more; greatest breadth about 4½ mm. The pterostigma is pale. A small leaf covers a portion of the middle of the wing, but fortunately does not hide anything of much importance. Station 13, Florissant, 1906. (*W. P. Cockerell.*) (Fig. 3.)

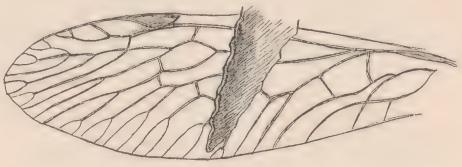


Fig. 3. *Megaraphidia elegans* sp. nov.

Easily distinguished from any of the Raphidiidæ described by Scudder by its much larger size.

TRICHOPTERA.

The fossil Trichoptera of Florissant are quite numerous, and have been discussed at length by Scudder, who recognized three genera and three species of Phryganeidæ, one genus with one species of Limnephilidæ, one genus with two species of Leptoceridæ, and eight genera and sixteen species of Hydropsychidæ. Unfortunately, however, many of the specimens are poorly preserved, so that accurate and detailed descriptions are impossible; and several species have not been figured. I have been allowed to examine the types (belonging to the Museum of Comparative Zoölogy) of several of the most obscure species described by Scudder, and the results are given herewith.

Phryganeidæ.

Phryganea labefacta *Scudder.*

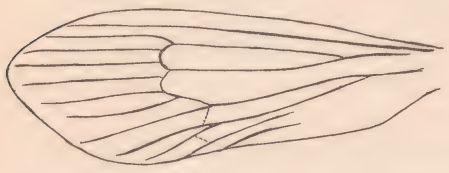
At Station 4 I found a very good specimen, showing most of the anterior wing. The characters agree with *Phryganea*, though the wing is quite broad, herein approaching *Neuronia*. The branches of the sector agree with *P. minor*, not with *P. grandis*, except that the second is closer to the third than to the first, at point of origin.

Wing reddish brown; radius with the bend distinct, about as in *P. minor*; first apical branch of sector parts from discoidal cell about 2½ mm. from apex, and 3½ from base (thus not at middle, as Scudder says — but his figure agrees with our specimen); lower border of discoidal cell straight or practically so (not as full as the upper, as Scudder says, but his figure agrees sufficiently with our insect); tip to base of first fork 9 mm.; length of discoidal cell 6 mm.; tip to base of discoidal cell almost 13 mm.; length of third fork 7 mm., of fifth, 6 mm. Probable length of wing about 20 mm; breadth 7¼ mm.

Limnephilidæ.

Platyphylax (**Eopteryx** n. subg.) **florissantensis** sp. nov.

Station 14, one good wing, with a less perfect reverse (Fig. 4). (The station is a little in doubt; it may have come from 13).



Flg. 4. *Platyphylax* (*Eopteryx*) *florissantensis* subg. et sp. nov.

Anterior wing of a uniform warm brown, 21 mm. long, 7½ broad, venation in most respects normal, but the following peculiarities are noteworthy: —

(1) The radius is perfectly straight to the end, not in the least bent; at apex it is only half as far from the uppermost branch of the sector as the latter is from the second branch.

(2) The discoidal cell is extremely long, a trifle over 9 mm.; its base is 5½ mm. from base of wing.

(3) The fifth apical fork is quite regular, its lower side not bent.

(4) The inferior cubitus runs to the margin parallel with the lower branch of the fifth fork, and is not suddenly or abruptly directed downwards; it forms a very acute angle with the margin of the wing. The transverse vein uniting it with the lowermost branch of the upper cubitus is so faint that I cannot be quite sure of its position. The postcosta is independent of the inferior cubitus.

The apical cells are of about equal width; apical forks 1, 2, 3, 5 present; cellula thyridii about 8 mm. long; base of seventh and eighth apical cells 3 mm. basad of base of fourth. The first branch of the sector is arched as it leaves the discoidal cell, as in *Halesus*. The seventh apical cellule is narrowly very obliquely truncate basally.

This seems nearest to *Platyphylax* in its characters, including the venation, the large size (probable expanse about 47 mm.) and the color. The straight radius, very long discoidal cell, and regular fifth fork, etc., are however peculiar, and all may be regarded as primitive characters, *i. e.*, as tending to a condition of simple radiating veins.

Mr. Nathan Banks and Dr. Cornelius Betten, whom I have consulted on the subject, both regard the fossil as representing a new genus; but since the characters are only moderately divergent from some forms of *Platyphylax*, and the leg-characters, so important in the classification of Trichoptera, are totally unknown, I think it may suffice to treat it as representing a distinct subgenus only. This subgenus (or genus)? may be termed **Eopteryx**.

Leptoceridæ.

Setodes abbreviata *Scudder.*

I have examined Scudder's type No. 5218. I had taken it for a moth,

probably an Elachistid, until I came to examine it minutely. The wings are black, pointed, and are covered with longitudinal cracks, which have nothing to do with the venation, the latter being obsolete; length of anterior wing about 4½ mm. Antennæ thick and very long (at least 6 mm.); their thickness near the base is about 119 μ, near the middle about 85 μ.

Abdomen pale, extending about 1870 μ beyond tips of wings.

The generic reference is necessarily provisional.

Hydropsychidæ.

Tinodes paludigena *Scudder.*

The specimen examined is Scudder's No. 2142 — not the one figured.

It is quite a doubtful insect. Length of anterior wing 6 mm.; costal region having a golden lustre; subcosta and radius would do for *Tinodes*, also base of median cell, but not the apparent first fork — but this is indistinct and dubious. The radius bends upwards at the end.

Polycentropus exesus *Scudder.*

Scudder's No. 3143 examined. All that can be seen agrees exactly with *Polycentropus*. Length of head and body 7 mm., of anterior wing 8 mm. Veins hardly infuscated; no dark subcostal shade (such as is seen in *P. æternus*); radius turning up a little at end, and exactly as in *P. flavomaculatus*; bases of discoidal and median cells exactly as in *P. flavomaculatus*; length of fifth fork 2⅓ or 2½ mm., with the bulging base exactly as in *P. flavomaculatus*; base of discoidal cell about 3¼ mm. from base of wing, and 4¾ from apex; length of first apical fork on its lower side 1190 μ; second fork about 2½ mm. long; distance between second and third branches of sector at level of middle of first fork about 238 μ.

Scudder's doubtful *Polycentropus* (?) *eviratus* I have not seen. The figure looks much like a moth; the wings heavily scaled, and no venation visible.

Polycentropus æternus (*Scudder*).

Derobrochus æternus Scudder; type = specimen No. 5308. I examined this very carefully, and do not see any reason for separating it from *Polycentropus*.

Length of anterior wing about 9½ mm.; a dark shade above the discoidal cell; the discoidal and median cells, and all the forks, are plainly visible. Apex of dis-

coidal cell about 3 mm. from end of wing (in straight line) and five from base; apex of median cell about $2\frac{2}{3}$ mm. from end of wing, and 6 or nearly from base; apex of median cell about 850 μ more apicad than that of discoidal; fifth fork about $2\frac{1}{2}$ mm. long, broad toward base.

The following measurements are in μ:—

Length of discoidal cell, about . . . . . 2550.
Width of discoidal cell near end . . . . . 510.
Beginning of fork of first two branches of sector (first apical fork) beyond end of discoidal cell . . . . . 1020.
Length of hairs, as seen in first fork, about . . . . . 85.
Distance between discoidal and median cells . . . . . 391.
Width of median cell near end . . . . . 340.
Origin of last nervure from median cell from (basad of) origin of the one before (*i. e.*, fourth fork on median cell) . . . . . 765.
Length of fourth fork about . . . . . 2295.
Length of third fork over 2550, but its apex about 680 less basad than that of fourth.
Length of first fork on its lower side . . . 1020 (*i. e.*, equalling its stem).
Width of first fork at level of termination of its upper side . . . 425.
Distance between second and third branches of sector:—
(1) At level of end of first branch . . . . . 306.
(2) At level of end of second branch . . . . . 476.
Distance between third and fourth branches of sector:—
(1) At level of end of second branch . . . . . 408.
(2) At level of end of third branch . . . . . 476.
Width of fourth apical cellule:—
(1) At 1700 from tip of wing . . . . . 425.
(2) At level of termination of its lower side on margin . . . 510.
Width of fifth apical cellule (third fork):—
(1) At 1700 from margin on its upper side . . . . . 340.
(2) At level of termination of its lower side on margin . . . 544.

The last branch of the sector ends almost exactly at tip of wing, as is the case in *Hydropsyche*.

I have given the above elaborate measurements partly to show that in this species, at least, the peculiar characters assigned to *Derobrochus* are not found; and partly because these fossils have to be determined frequently from imperfect material, and in such cases an exact knowledge of the various proportions is essential.

Derobrochus commoratus *Scudder.*

Specimen examined, Scudder's No. 14171. This is not precisely a *Polycentropus*, but perhaps hardly a distinct genus. Scudder says the neuration is as in *D. æternus*, but it is not so exactly; the fourth branch of the sector arises much more basad, the first apical fork has a very much shorter stem, and the third fork has a short but distinct stem. It is also a

more slender winged species; anterior wings about 9 mm. long and $2\frac{3}{4}$ broad. The base of the third apical fork is on a level with that of first. Length of first fork on its lower side about 1 mm., or slightly more. Discoidal cell long. Third nervure from median cell a little nearer to fourth than to second.

Derobrochus cænulentus *Scudder.*

Specimen examined, Scudder's type, No. 14444.

Length of head and body just over 8 mm.; anterior wing long and narrow, 9 mm. long, $2\frac{3}{4}$ broad; wing strongly hairy; apex a *little* above middle. First apical fork about $\frac{2}{3}$ mm. long on its lower side; second apical fork about $2\frac{1}{3}$ mm. long on its lower side, but its base cannot be exactly located; end of fourth branch of sector at apex of wing or just above; length of third apical fork $1\frac{3}{5}$ mm.; length of nervure from middle of apical side of median cell $1\frac{1}{4}$ mm.

Forks 1 and 2, as also the shape of the wing, would agree with *Triænodes.*

However, I seem to see a median cell, much as in *Hydropsyche,* but its outer border straight, giving off a nervure in middle of border as in *Hydropsyche*; I also see third fork from its upper corner, as in *Hydropsyche.*

The insect is nearer to *Hydropsyche* than to *Polycentropus,* and may be a slender species of the former genus.

Derobrochus abstractus *Scudder.*

Specimen examined, Scudder's type, No. 9377. This is the first species of *Derobrochus,* and must be considered its type, no statement being made to the contrary.

Shape of wings agrees fairly well with *Polycentropus.* Discoidal cell evidently very long, probably about 4 mm.; apex of discoidal cell from apical margin in straight line 3 mm., but to apical point 4 mm., and to base about 7 mm. Scudder says, "the first apical cell is remarkably long"; so it is, the first fork having a length of 2805 μ on its lower side.

The following measurements are in μ.

Width of first apical cellule at level of the termination on margin of its upper side	340.
Width of second apical cellule at level of termination of upper side	425.
Width of third apical cellule at level of termination of upper side of second	510.
Width of fourth apical cellule:—	
(1) At level of termination of upper side of second	510.
(2) At 1700 from apex of wing	340.
Width of fifth apical cellule a short distance from end	510.
Width of sixth apical cellule 850 from margin (counting on its upper side)	510.

The rest of the wing is obscured, partly by overlapping. The insect

seems not to be a Hydropsychid; according to the character of the first apical cell it could come near *Lepidostoma* (Sericostomatidæ) or *Stenophylax* (Limnephilidæ). It is safe to say that it is not congeneric with the other three species described above.

There remain three species of *Derobrochus* which I have not seen. Scudder's figures of *D. craterœ* and *D. frigescens* plainly show the fifth apical cell (third fork), which is supposed to be absent. Some of the venational characters shown in the figures appear to be inaccurate.

HYMENOPTERA.

Chalcididæ.

Chalcis prævolans sp. nov.

♀. Length 5 mm.; expanse of wings 7 mm.; head and thorax black, legs dark brown, abdomen somewhat reddish, apparently with linear light transverse bands; wings slightly infuscated, reddish; head broad, its breadth about 1¼ mm.; thorax stout, globose, almost 2 mm. broad, with very large strong punctures, close together; abdomen nearly 3 mm. long, narrow (like some *Haltichella*), its breadth about or scarcely over 1 mm., the sides subparallel, the ovipositor slightly exserted, its apex broad and rounded; hind femora very stout, about 525 μ diam. in middle; length of hind femur about 1200 μ; hind tibiæ stout, quite 255 μ broad; veins all very pale, submarginal 1125 μ long, marginal 375, stigmal 135, postmarginal 240. (Fig. 5.)

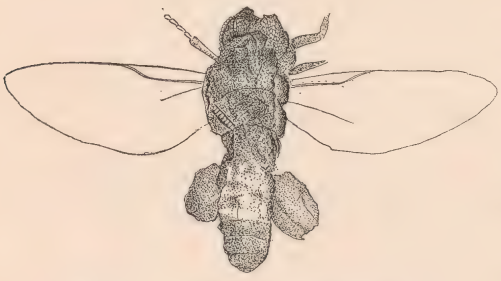


Fig. 5. *Chalcis prævolans* sp. nov.

Station 12 (*S. A. Rohwer*). One example, with reverse. I learn from Mr. Brues that this is also represented from Florissant in the Scudder collection.

Tenthredinidæ.

Subf. Emphytinæ.

Pseudosiobla megoura sp. nov.

Length 16 mm.; head and thorax were apparently black, small compared with abdomen, which is nearly 12 mm. long and 5 broad, pale, with a broad dark band on each segment; wings hyaline, with dark nervures.

Venation of anterior wings almost as in *P. excavata* (MacGillivray, Pr. U. S. Nat. Mus., XXIX, pl. xxviii, f. 48), but differing in slight particulars, as follows:—

(1.) Stigma narrower, hardly so bulging below.

(2.) Costal cell more evident, more as in *Eriocampa*.

(3.) Cross nervure of marginal cell entirely as in *Pseudosiobla*, but third t. c. (R_4) joining marginal nervure much further (850 μ) beyond it.

(4.) First submarginal cell a little more produced basally.

(5.) Interval between origin of cubital nervure and insertion of basal somewhat greater (510 μ).

(6.) Basal bend of third (second, Norton) anal nervure very light. The oblique of lanceolate cell is normal, except that it is less oblique; it is 510 μ long, the distance straight across the cell at this point being 425 μ. Its upper end is 1462 μ from lower end of transversomedial.

The following measurements are in μ:—

Length of first submarginal cell	884.
Length of basal nervure	1275.
Length of first discoidal cell (diagonally)	2652.
Basal nervure from transversomedial	374.
Lower side of first discoidal (b. n. to origin of first r. n.)	1734.
Length of second recurrent nervure	1275.
First s. m. on cubital nervure	850.
First t. c. to insertion of first r. n.	510.

The venation of the posterior wing cannot be ascertained.

Station 13.

The genus is represented in the modern fauna by a species of the northern States, from Illinois to Massachusetts.

Subf. Tenthredininæ.

Tenthredo submersa sp. nov.

Length about 13 mm.; of the usual form; head and thorax apparently black; the abdomen was probably red, its width is about 3½ mm.; venation light brown.

Anterior Wing.

Lanceolate cell. In general like *Tenthredo*, with straight cross-nervure, the cell contracted to the cross-nervure, so that the latter is only about as long (102 μ) as broad; apical part of lanceolate cell (*i. e.*, beyond the cross-nervure) about 2720 (this and the following measurements in μ) long and 425 broad in the middle; nervure $M_4 + Cu_1$ (t. m.) entering about 1309 from apex.

Median cell large, 595 high, its apex not much produced, the basal nervure (about 595 long) at an angle of more than 45°. This is more like *Stromboceros*.

Costal cell widest (340 wide) opposite insertion of basal nervure, the cross-nervure indistinct, but placed as in *Tenthredo*, that is, not very far from basal.

Submedian cell shaped as in *Tenthredo*, but there is a distinct bend in the externomedial nervure about 850 from the origin of the basal. From l. n. to t. m. is about 340, and t. m. is about 731 long.

First discoidal cell large, shaped as in *Tenthredo,* but base blunter; about 2771 long.

Second discoidal as in *Tenthredo,* but the apex rather more produced.

Third discoidal as in *Tenthredo,* the upper basal side 1020 long, lower basal 680.

First submarginal cell cuneate, much longer than in *Tenthredo,* 1105 long, about 476 broad at broadest point, the first t. c. about 289 long.

Second submarginal on marginal nervure 1530. Insertion of second t. c. to junction of cross-nervure of marginal cell with marginal nervure, 850.

Posterior Wing.

Lanceolate cell shaped as in *Tenthredo,* about 561 broad in middle, but not touching first apical cell, being separated from it by a nervure about 170 long, thus more like *Macrophya.*

Agrees in all important respects with *Tenthredo* as figured by MacGillivray, Proc. U. S. Nat. Mus., XXIX, pl. xxxi, f. 56.

Station 14, a good specimen, with reverse. A small leaf of *Planera longifolia* is on the same slab, about 10 mm. from the insect.

Vespidæ.

Palæovespa scudderi *Ckll.*

At Station 13 I found a good example referred to this species (Fig. 6). It is about 22 mm. long; anterior wing about 14 mm.; eyes visible, and as in type.

This is larger than the type, and I think a queen.

The following wing measurements are in μ, unless the contrary is stated:

Length of first discoidal cell about 6⅓ mm.; marginal cell pointed; insertion of third t. c. to tip of marginal 1200; third s. m. on marginal about 840; second s. m. on marginal about 570; marginal nervure to insertion of basal, 600; basal nervure inserted at base of stigma; first (apicad) section of b. n. 1200; insertion of first t. c. to stigma, that is first s. m. on marginal, about 1125; lower side (on discoidal) of first s. m. about 2250; lower edge of second s. m. (from lower corner of apex to discoidal) about 1050; insertion of second r. n. to beginning of second t. c., 300. The end of first discoidal is scarcely more oblique than in *Vespa.*

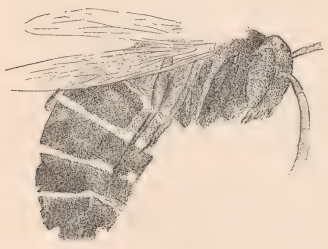


Fig. 6. *Palæovespa scudderi* Ckll.

Sphecidæ.

Subf. Sceliphroninæ.

Chalybion mortuum sp. nov.

Length 18 mm., of which 10 is head and thorax; the abdomen is retracted and directed downwards, if it were fully extended the insect would doubtless measure 20 mm.; anterior wing about or nearly 11 mm.; hind femora 4 or slightly more; hind tibiæ $4\frac{1}{2}$, the spines very little if at all developed; hind tarsi about 7, without evident spines; claws with a single tooth beneath. Black, as preserved, but possibly originally metallic; wings subhyaline, with a large diffused cloud extending from the marginal to the apical part of the third discoidal cell. Prothorax with striæ; metathorax with transverse striæ; petiole of abdomen 2 mm. long or slightly more, rather thick, rest of abdomen oval, short. Antennæ not preserved.

Venation normal, with slight exceptions. *The marginal cell extends conspicuously beyond the third submarginal*; the second submarginal is narrow, higher than broad, and receives both recurrent nervures, but the second at extreme apex; the second recurrent nervure is arched, *and the outer lower corner of the third discoidal cell is not produced, but forms an obtuse angle within.* The characters italicised may be regarded as primitive, that is, as approaching the more normal type of venation for the aculeate Hymenoptera.

The following wing measurements are in μ:—

Length of marginal cell	2516.
Breadth " " "	680.
Depth of stigma "	340.
Marginal cell beyond level of apex of third s. m.	about 306.
Third s. m. on marginal	680.
Second " " "	357.
First " " "	561.
" " " basal nervure	357.
Total length of first s. m.	2550.
Lower side of second s. m.	680.

First r. n. joining second s. m. about 240 from base; second joining at extreme apex, practically meeting second t. c.

Basal nervure falling about 153 μ short of transverse-medial.

The venation is not very unlike that of *Hoplisus sepultus*, also fossil at Florissant, but it will be easily distinguished by the form of the second submarginal cell. From *Ceropalites*, the present insect is easily known by the character of the region of the basal nervure. The lower section of the b. n. in *C. mortuum* is many times longer than the upper, as is normal for the genus.

Kohl makes *Chalybion* a mere group of *Sceliphron*. The evidence of its antiquity herewith presented may be regarded as favoring its validity as a genus.

Station 14; one very good example.

Chrysididæ.

Chrysis rohweri sp. nov.

Robust, of ordinary size and form, with the normal venation (very well preserved) of the genus; apex of abdomen broadly truncate, the edge slightly concave. Length about 6 mm.; anterior wing 4. The wings hyaline, with dark nervures; marginal cell rather narrow, the bend of the marginal nervure hardly perceptible, the curve of the nervure not far from uniform; thorax and first abdominal segment with very strong large punctures (preserved as raised warts), about eight in a straight line transversely between the parapsidal grooves, about six in a straight line from anterior to posterior margin of scutellum, those on scutellum and metathorax somewhat larger than those on mesothorax and first abdominal segment; on the apical half of the first abdominal segment the punctures are weaker, and the rest of the abdomen is merely finely roughened.

Florissant, Station 14, June, 1907 (*S. A. Rohwer*).
Type in American Museum of Natural History.

56.52(78.8)

Article XXV.—SOME COLEOPTERA AND ARACHNIDA FROM FLORISSANT, COLORADO.

By T. D. A. Cockerell.

On previous occasions (*cf.* Bull. Am. Mus. Nat. Hist., XXII, p. 420) attention has been called to the fact that Florissant, notwithstanding its high altitude (about 8000 ft.), is rich in austral elements. It must be considered to belong to the upper part of the Transition Zone rather than to the Canadian. In 1906 I was able to collect small series of beetles and spiders, which have been very kindly determined by Messrs. H. C. Fall and N. Banks respectively; and it is thought worth while to present the lists herewith, owing to their bearing on the zonal position of Florissant. I have given particulars of the distribution elsewhere in the State of most of the species, and it will be seen at once that the great majority reach the edge of the plains, — that is, go practically to the *lower* limit of the Transition, as at Fort Collins, Denver, Colorado Springs, etc. Some, while ranging downwards to Buena Vista, etc., seem, like the plant *Hymenoxys*, to belong to the *west* side of the front range in the latitude of Florissant.

The asterisks before the names of the families and genera indicate that these have been found fossil in the shales.

COLEOPTERA.

*Carabidæ.

***Bembidium bifossulatum** *Lec.* Colorado Springs, Denver, etc.

Bembidium bimaculatum *Kirby.* Apparently a Canadian Zone species, but down to Buena Vista.

Bembidium lucidum *Lec.* Colorado Springs, etc.

Bembidium fuscicrum *Mots.* Salida, Buena Vista, etc.

***Platynus errans** *Say*, var. Salida, Buena Vista and South Park.

Platynus cupreus *Lec.* South Park and San Luis Valley.

Lebia viridis *Say.* Colorado Springs, etc. Extends to Guatemala.

Lebia scapularis *Dej.* San Luis Valley.

Cymindis planipennis *Lec.* Denver, Colorado Springs, etc. I have taken it at Boulder.

***Harpalus amputatus** *Say.* Denver, etc.

Harpalus furtivus *Lec.* Manitou, etc.

*Dytiscidæ.

Hydroporus rivalis *Gyll.* I did not take this, but Florissant is the type locality of the var. **congruus** *Lec.* (Bull. Hayden Surv., IV, 452).

***Agabus strigulosus** *Lec.* Florissant is the type locality of var. *nanus* Lec.

Colymbetes sculptilis *Harr.* Fort Garland.

*Hydrophilidæ.

Berosus infuscatus *Lec.* Previously known vaguely from "Colorado."

Laccobius agilis *Rand.* is recorded by Wickham from Florissant.

*Silphidæ.

***Silpha ramosa** *Say*, near Denver, etc.

*Staphylinidæ.

***Quedius explanatus** *Lec.* New to Colorado.

*Coccinellidæ.

Hippodamia parenthesis *Say.* Denver, etc.

Coccinella transversoguttata *Fab.* Fort Collins, etc.

Helesius nigripennis *Lec.* Florissant is the type locality (Bull. Hayden Surv. IV, 453).

Cryptophagidæ.

Antherophagus pallidivestis *Csy.* New to Colorado.

*Dermestidæ.

Orphilus ater *Er.* Halfway House, Pike's Peak.

*Histeridæ.

Saprinus oregonensis *Lec.* Colorado Springs, etc.

*Nitidulidæ.

Meligethes mutatus *Har.* Colorado Springs, etc.

*Elateridæ.

Hemicrepidius, probably new.

*Buprestidæ.

Chalcophora angulicollis *Lec.* Fort Collins, etc.

Buprestis consularis *Gory.* Colorado Springs, etc.

*Lampyridæ.

Telephorus lineola *Fabr.*?

Telephorus alticola *Lec.* The only other Colorado record is Garland.

Malthodes furcifer *Lec.* Veta Pass.

MALACHIIDÆ.

Listrus senilis *Lec.* Colorado Springs, etc.
Pseudallonyx plumbeus *Lec.* Beaver Brook, 6390 ft.

*CLERIDÆ.

Hydnocera subfasciata *Lec.* Colorado Springs, etc.

*SCARABÆIDÆ.

Canthon praticola *Lec.* Colorado Springs, etc.
Canthon simplex *Lec.*
Aphodius hamatus *Say.* Buena Vista, etc.
Aphodius fimetarius *L.* I have taken it at Boulder.

*CERAMBYCIDÆ.

Phymatodes dimidiatus *Kirby.* Usually at high altitudes.
Neoclytus muricatulus *Kirby.* Fort Collins, etc.
Acmæops pratensis *Laich.* Colorado Springs, etc.
Tetraopes canescens *Lec.* Colorado Springs, etc.

*CHRYSOMCLIDÆ.

Coscinoptera vittigera *Lec.* Colorado Springs, etc. I have taken it at Boulder.
Plagiodera n. sp.? Also occurs in New Mexico.
Galerucella decora *Say.* Colorado Springs, etc.
Phyllobrotica decorata *Say.* Ft. Collins, near Boulder, etc.
Luperodes n. sp.
Chætocnema sp.

*BRUCHIDÆ.

Bruchus fraterculus *Horn.* I have taken it at Boulder.

*TENEBRIONIDÆ.

Blapstinus sp.

PYTHIDÆ.

Lecontia discicollis *Lec.* Fort Collins, etc.

*MORDELLIDÆ.

Anaspis rufa *Say.* Colorado Springs, etc., but usually at high altitudes. I took it at Ward, 9000 ft.
Mordella scutellaris *Fab.* Colorado Springs, etc., but goes to high altitudes.

*MELOIDÆ.

Nemognatha lutea *Lec.* Colorado Springs, etc.
Epicauta maculata *Say.* Colorado Springs, etc.

*Curculionidæ.

Hyperodes sp.

***Cleonus grandirostris** *Csy.* New to Colorado; it has been found in New Mexico.

Pnigodes sp. apparently new. "Our only species of the genus is *setosus*, described long ago from Texas. The description applies well to this, except that this lacks the erect setæ completely." (H. C. Fall.)

ARACHNIDA.

Pholcidæ.

Psilochorus pullulus *Hentz.* Ft. Collins, etc.

*Drassidæ.

Micaria perfecta *Banks.* Ft. Collins.

Micaria montana *Emert.*, or possibly new. "It agrees very well with N. H. specimens, but is paler; ♂ might show specific differences" (N. Banks). New to Colorado.

*Clubionidæ.

Castaneira descripta *Hentz.* New to Colorado.

*Theridiidæ.

Lithyphantes corollatus *Koch.* Fort Collins, etc., but also as high as Leadville.

*Epeiridæ.

***Tetragnatha laboriosa** *Hentz.* Fort Collins, etc.

*Thomisidæ.

Xysticus nigromaculatus *Keys.* Fort Collins. A rare species.
Oxyptila conspurcata *Thor.* Fort Collins, etc.
Misumena vatia *Clerk.* Fort Collins, etc.
Philodromus aureolus *Walck.* Fort Collins, etc.

Lycosidæ.

Pardosa glacialis *Thor.* New to Colorado.

*PHALANGIDA.[1]

Homolophus biceps *Thor.* Fort Collins, etc.

PSEUDOSCORPIONIDA.

Obisium sp., probably new. Genus new to Colorado.

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[1] No fossil Phalangid has been reported, but *Leptobunus atavus* Ckll. was found in 1906.

ACARINA.

Trombidium sericeum *Say.* Fort Collins, etc.
Actineda agilis *Banks.* Fort Collins.
Rhyncolophus robustus *Banks.* Type locality is Fort Collins.
Phyllocoptes populi. In galls (shallow subcircular cavities with thickened hairs) on leaves of *Populus tremuloides*. Mr. Banks says the galls and mites agree with this European species, but he has no European specimens of the mites.

Three Diptera new to Colorado were determined by Mr. Coquillett; *Tersesthes torrens* Townsend, from Lake George June 18; and *Scatopse notata* L. and *Psilocephala munda* Loew, from Florissant. The bug *Dicyphus californicus* Stål was taken at Florissant July 3, and determined by M. Heidemann. The Coccid *Erium lichtensioides* (Ckll.) was common on *Artemisia*.

56.4,1U(117:78.6)

Article XXVI.—REMARKS ON AND DESCRIPTIONS OF NEW FOSSIL UNIONIDÆ FROM THE LARAMIE CLAYS OF MONTANA.

By R. P. Whitfield.

Plates XXXVIII–XLII.

The few species of *Unio* included in this article are from the Laramie clays, 130 miles northwest of Miles City, Montana, from a bed located about 180 feet above the Fort Pierre shales, and consequently well above the recognized Cretaceous horizon.

The shells are fairly well preserved and retain the nacreous coloring to a great extent, though the outer epidermal coating is usually absent and not infrequently the prismatic outer layer is partly absent or frequently crumbles on being washed. The clay beds in which they are found are horizontal, and usually undisturbed, except by the weathering and washing consequent upon the weathering.

These shells are from near the same locality as the six species described in Volume XIX of this Bulletin (pp. 483–487), but come from a somewhat higher level above the Pierre, being at about 400 feet above the shale. Among those previously described, three of the species so closely resemble living species known from the western river water-shed, that I gave them names indicating these resemblances. In this lot occur four others that have similar resemblances, namely, *U. biæsopoides* from *U. æsopoides* of the first lot, differing from it in having a double line of nodes along the umbonal slope, instead of only one. The others resemble respectively *U. pyramidatus*, *U. cylindricus*, *U. cornutus* and *U. gibbosus*.

Among other species common in the same localities and clays one of the most abundant forms is usually referred to *U. danæ* Meek and Hayden but which I think is much more closely allied to *Unio gibbosus* Barnes, of the Ohio and Mississippi Rivers. It differs materially from Meek's figures of *U. danæ*, in not possessing the radiating striæ shown quite conspicuously there as given in Vol. IX, Geol. Surv. Territories, pl. 41, figs. 3*a* and 3*c*, but do not appear on C. A. White's fig. 2*a*, plate 27, Contributions to Palæont., 1880, but do appear on those copied from Meek's in White's, 'Non Marine Mollusca', Third Ann. Rept. U. S. Geol. Surv., 1881–82, pl. 17, figs. 1 and 2, but again do not on those given on pl. 18, figs. 1 and 2.

These Laramie shells from this Montana locality, are so closely similar

to those from the Ohio River localities that I propose to designate them by the name *U. gibbosoides.*

Considering all the similarities between these Laramie fossils and their representative species in the Mississippi and Ohio water-sheds, I venture to state that these further western waters of the Laramie times were the original home of much of the *Unio* fauna of these more eastern recent localities.

From this locality, 130 miles northwest of Miles City, Montana, we have the following species, represented by closely allied forms, some of them so nearly like the living species, that it would do but little violence to specific features, to state they were the same, namely:

Unio æsopiformis	resembles	*U. æsopus* Green.
Unio letsoni	"	*U. cornutus* Barnes.
Unio cylindricoides	"	*U. cylindricus* Say.
Unio gibbosoides	"	*U. gibbosus* Barnes.
Unio pyramidatoides	"	*U. pyramidatus* Lea.
Unio retusoides	"	*U. retusus* Lam.
Unio verucosiformis	"	*U. verrucosus* Barnes.

Unio biesopoides, n. sp.

PLATE XL FIG. 7, and PLATE XLI, FIG. 8.

Shells like those of *U. æsopoides* in all essential particulars, internal and external; except that it presents two distinct lines of nodes leading from near the beaks backwards to the posterior basal angle instead of only a single line of nodes as also in the recent or living species *U. æsopus,* the second line being on the umbonal angle.

Locality and *formation.*— Laramie beds, 130 miles northwest of Miles City, Montana, 180 feet above Pierre shales. Barnum Brown, collector.

Unio pyramidatoides n. sp.

PLATE XLI, FIGS. 1–5.

Shell somewhat resembling the living *U. pyramidatus* in general features, but more erect, narrower across the body of the shell, in an anterior-posterior direction, and without the sulcus on the posterior umbonal slope; or at least having it less developed or very narrow and shallow, while the posterior margin is flattened and the umbonal ridge decidedly angular and often subcarinate; the lunule being quite small or usually nearly obsolete, and the beaks, when not eroded, show a decided zigzag or doubly V-shaped system of corrugation. Internally the shells are remarkably heavy and thickened, making the teeth and all internal features even larger and proportionally thicker and deeper than in the living representative species. The posterior lateral teeth are usually more curved.

Locality and *formation.*— Laramie beds, 130 miles northwest of Miles City, Montana, 180 feet above Pierre shales. Barnum Brown, collector.

Unio pyramidellus n. sp.

PLATE XL, FIGS. 3 AND 4.

Shell small, very erect, from beak to base, and mostly less than one and one fourth inches high; disc of the valves rather depressed convex, with a slight sulcus crossing from the beak to the posterior angle quite near the posterior margin. Beak proportionally heavy, tumid, directed forward; anterior margin slightly concave, posterior margin slightly convex, basal margin broadly rounded. Internal features thickened, hinge plate and lateral tooth in the right valve large, the plate broad and slightly concave in the best preserved valve, and the lateral tooth much curved and thickened. Cardinal tooth triangular, proportionately large, cuneiform above, below divided by three vertical grooves, the socket having four ridges to fit against the large tooth of the opposite valve. Anterior muscular impression small, but deep, the secondary small and shallow, close to the former. Posterior impression long, narrow and moderately distinct. Surface of the disc smooth except for distinct growth lines.

The shells are poorly preserved and mostly much distorted by compression, but all show a much bent hinge plate and strong teeth, the cardinal tooth being low down near the middle of the anterior border, and the long lateral tooth and posterior scar extending below the middle of the height.

Locality and formation.— Laramie beds, 130 miles northwest of Miles City, Montana, 80 feet above Fort Pierre shales. Barnum Brown, collector.

Unio gibbosoides n. sp.

PLATE XL, FIGS. 1 AND 2.

Shell transverse, compressed, much wider than high, and resembling in nearly all respects *U. gibbosus* of Barnes, as it occurs in the Ohio and Mississippi Rivers at the present time, both externally and internally.

It has been commonly referred to as *U. danæ* Meek & Hayden which it closely resembles, but it never shows the radiating striæ which that species quite generally does, passing obliquely backward across the valves from the beaks to the basal boarder along the depressed middle portion of the valves. In most other respects the two species are closely allied.

Locality and position.— In Laramie Clay, about 120 feet above Pierre shales, on Snow Creek, on the Missouri River, in Montana.

Unio subtrigonalis n. sp.

PLATE XL, FIGS. 5 AND 6.

Shells small, triangular, ventricose cuneate, pointed behind, seldom exceeding an inch and an eighth in an anterior and posterior line, sharp and subangular on the umbonal ridge, with a nearly vertical posterior slope, which is slightly sulcated in front of the umbonal ridge; otherwise the disc is smooth or marked only by growth lines; base broadly rounded; beaks anterior, moderately heavy. On the interior the hinge plate is abruptly bent at some distance behind the beak, and the lateral teeth are thin and erect, while the cardinals are heavy and much corrugated. Anterior muscular imprint small but moderately deep, the posterior scar elongate, faintly marked and situated on the inside of the vertical cardinal slope.

The species is exceedingly like *Corbicula subtrigonalis* C. A. White, externally; but is decidedly and unmistakably a *Unio*, and not a *Corbicula*.

Locality and formation.— In Laramie ferruginous marls, 130 miles northwest of Miles City, Montana, 80 feet above Pierre shales. Barnum Brown, collector.

Unio cylindricoides n. sp.

PLATE XXXVIII, FIGS. 1–7; PLATE XXXIX, FIGS. 1–3.

Shell attaining a moderately large size, the adult shell being fully as large as full-grown specimens of the living *U. cylindricus*, which it resembles in size, form and general features, except in lacking the characteristic sculpturing of the surface. The largest individual in the collection was, when entire, fully four and one fourth inches in length. The shells are externally decidedly elongate-rhombic, much swollen along the umbonal ridge, which is sometimes quite angular. The beaks are enrolled and placed well forward, but not terminal, the outline of the figure being highest below the middle of the height anteriorly, while the living form is generally highest centrally. Posteriorly the reverse is the general rule in the fossil form, highest above the center and sharply rounded. The middle of the disc is broadly sulcated from the beaks to the basal margin, the sulcus covering the entire middle third of the shell.

No surface sculpturing exists on the larger specimens, but on the young and medium sized individuals, there is a system of raised ridges indicating or foreshadowing all of the markings of the living examples of *U. cylindricus*, except the nodes on or near the umbonal ridge, posteriorly to the end of the shell.

Internally all the features of the living form are present and so closely similar that it seems unnecessary to recapitulate them.

Locality and formation.— In muddy shales of the Laramie formation, 130 miles northwest of Miles City, Montana, 180 feet above Pierre shales. Barnum Brown, collector.

Unio letsoni n. sp.

PLATE XLII, FIGS. 1–4.

Shell rather below medium size for the genus, circular or broadly transversely oval in outline, and quite ventricose, but not globular. Beaks moderately large, nearly central, slightly oblique and but little enrolled. Surface of the shells highly ornamented except on the antero-basal quadrant, where there are only strong concentric lines of growth. Along the center of the valves from beak to base, there runs a line of strong heavy nodes usually numbering four on adult shells, where the height from beak to base will be about or a little more than one and a half inches, or nearly four cm. where the transdiameter, from anterior to posterior of the outline will be about, or over, four and a half cm., or somewhat more than one and three-fourths inches. Posterior to the median line of nodes and on the umbonal third of the shell there is always a double set of oblique depressed lines which give to this part of the shell the structure of a very coarse file. On the posterior half of the shell there is a system of oblique undulations or plicæ, which extends from the posterior side of the median line of nodes, gradually turning backwards and extending to the posterior margin of the valve and to the cardinal and basal edges of the shell, growing larger with the increasing growth of the valve. On the larger valve figured, these plications are sixteen in number, those of the beak portion being quite small and strongly curved towards the hinge. Between this set of markings and the central ridge there is usually another set of small ridges running between the starting of the posterior plicæ and the central ridge, passing from the ends of the posterior ridge towards the anterior basal border and forming with the posterior plicæ a series of very acute angles. These acute-angled ridges are most distinct on young individuals, often becoming faint from erosion on the older ones. On a single young individual of about an inch in height, there occur two small accessory nodes on each side of what would be the second node of the line on larger specimens.

Interiorly the valves are deep, and of a brownish pearly color. The cardinal teeth are well developed, the hinge plate wide, the laterals curved and moderately high, and the space between the cardinals and the laterals somewhat flattened. The muscular scars are distinct and rather deep.

Locality and formation.— Laramie beds, 180 feet above Pierre shales, 130 miles northwest of Miles City, Montana. Barnum Brown, collector.

This species in many of its features somewhat closely resembles or typifies *U. cornutus* Barnes of the Mississippi and Ohio water-sheds, and forms another species with closely related resemblances. The species is named in honor Dr. E. J. Letson, the eminent conchologist in charge of the Collection of the Buffalo Society of Natural History, Buffalo, N. Y.

Unio corbiculoides n. sp.

PLATE XLI, FIGS. 6 AND 7.

Shell small, rather below the average of the genus, subcircular in outline, ventricose, smooth, except for growth lines and two faint ridges shown on the posterior

cardinal slope and so obscure as to readily escape observation. A few faint corrugations are seen on the posterior surface of the beaks. Length of the shell, from the anterior to the posterior margin, slightly exceeding the height from beak to base. Posterior margin slightly flattened vertically, which on single valves has a tendency to give a somewhat subquadrangular outline, scarcely perceptible on the uncompressed shell. Lunular space deeply sunken, narrow, but very marked and disdinct; ligamental area deep, sharply margined. Beaks tumid when not eroded, faintly corrugated.

Interiorly the hinge plate is strongly bent, the lateral teeth curved, the cardinals strong and proportionally heavy, none of them have these features well enough preserved to present details. Muscular scars faint and the shells rather thin.

Locality and formation.— Laramie group, 130 miles northwest of Miles City, Montana, 80 feet above Pierre shales. Barnum Brown, collector.

EXPLANATION OF PLATE XXXVIII.

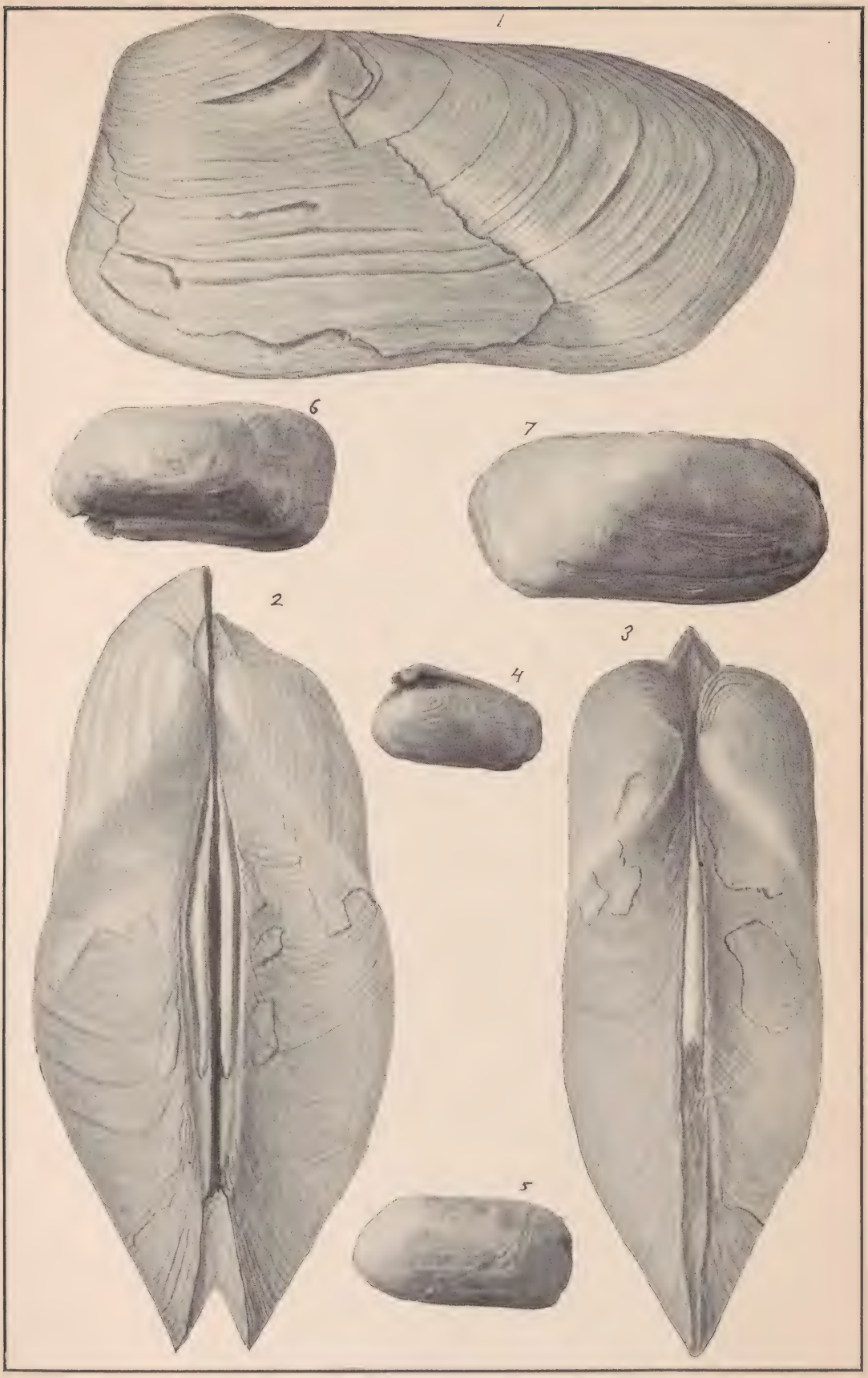
UNIO CYLINDRICOIDES n. sp. Page 626.

Fig. 1. View of the left valve, natural size, preserving a patch of the outside shell.

Fig. 2. Cardinal view of another specimen, natural size. The anterior end of the right valve is considerably broken. This shell probably being a female is much more ventricose than the other.

Fig. 3. Cardinal view of a male shell. The shell has mostly lost the outer prismatic layer.

Figs. 4–7. Views of four shells of different sizes or ages, on which the natural sculpturing is more or less preserved, but is not fully shown, as the photographs fail to show them. On the umbonal ridge the line of nodes was expected to be visible but is not.



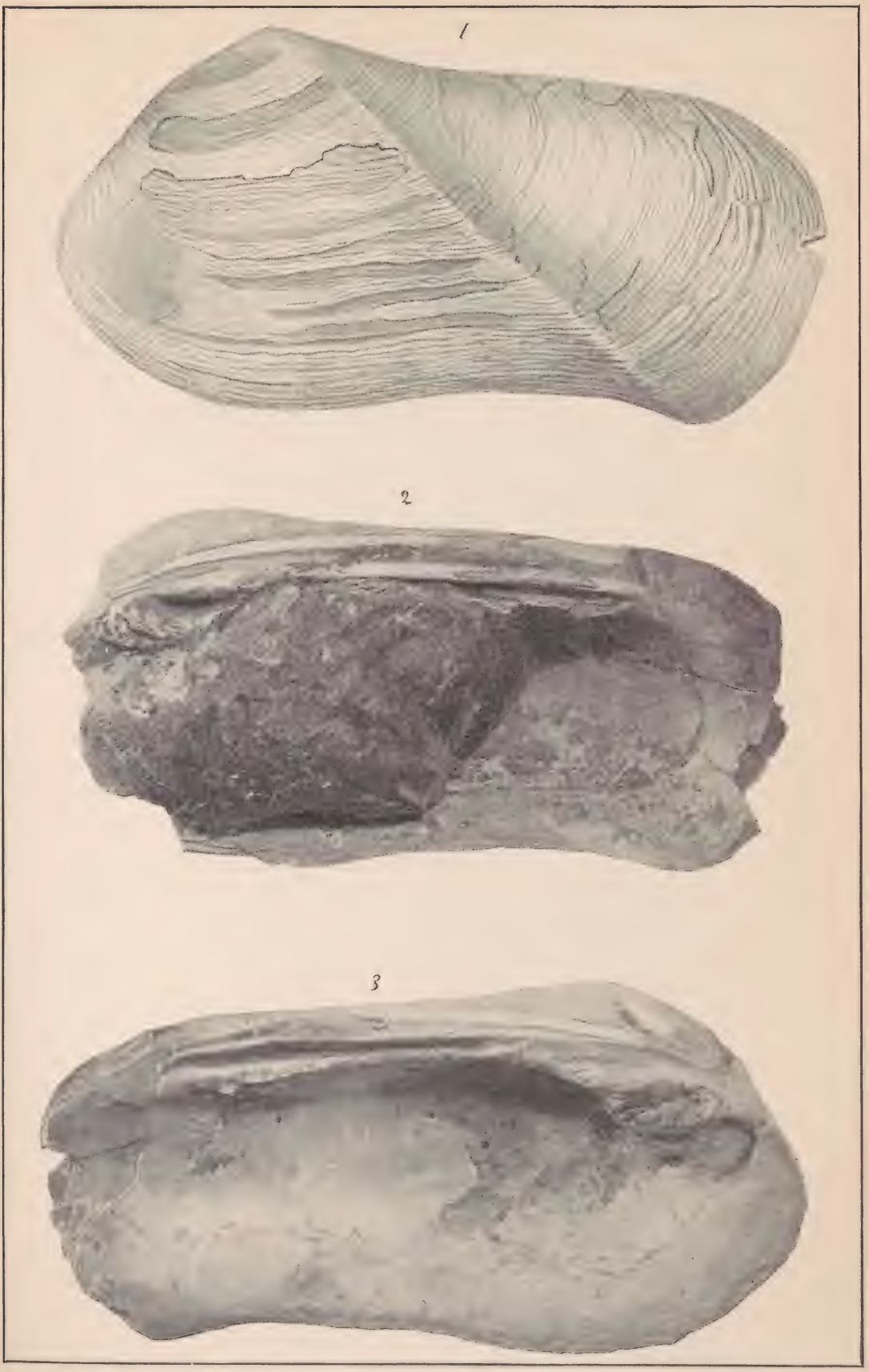
New Fossil Unionidæ.

EXPLANATION OF PLATE XXXIX.

UNIO CYLINDROCOIDES n. sp. Page 626.

Fig. 1. Left valve of the specimen shown in Plate XXXVIII, Fig. 2, natural size, showing the difference in what is supposed to represent a female form of the species; compare with Figs. 1 and 3, Plate XXXVIII. The outside of the shell has the surface more or less destroyed by decay.

Figs. 2 and 3. Views of the interior of the valves, right and left, of the same specimen represented in Fig. 1, where the outline is more or less restored. The figures show the teeth and muscular scars. Fig. 2 contained a partial cast of black chert when the photograph was made but which was subsequently removed.



New Fossil Unionidæ.

EXPLANATION OF PLATE XL.

UNIO GIBBOSOIDES n. sp. Page 625.

Fig. 1. Outside view, natural size, of an entire right valve, showing the general features.

Fig. 2. View of the interior of another and slightly smaller valve.

UNIO PYRAMIDELLUS n. sp. Page 625.

Fig. 3. Exterior, natural size.

Fig. 4. Interior of the same specimen, natural size.

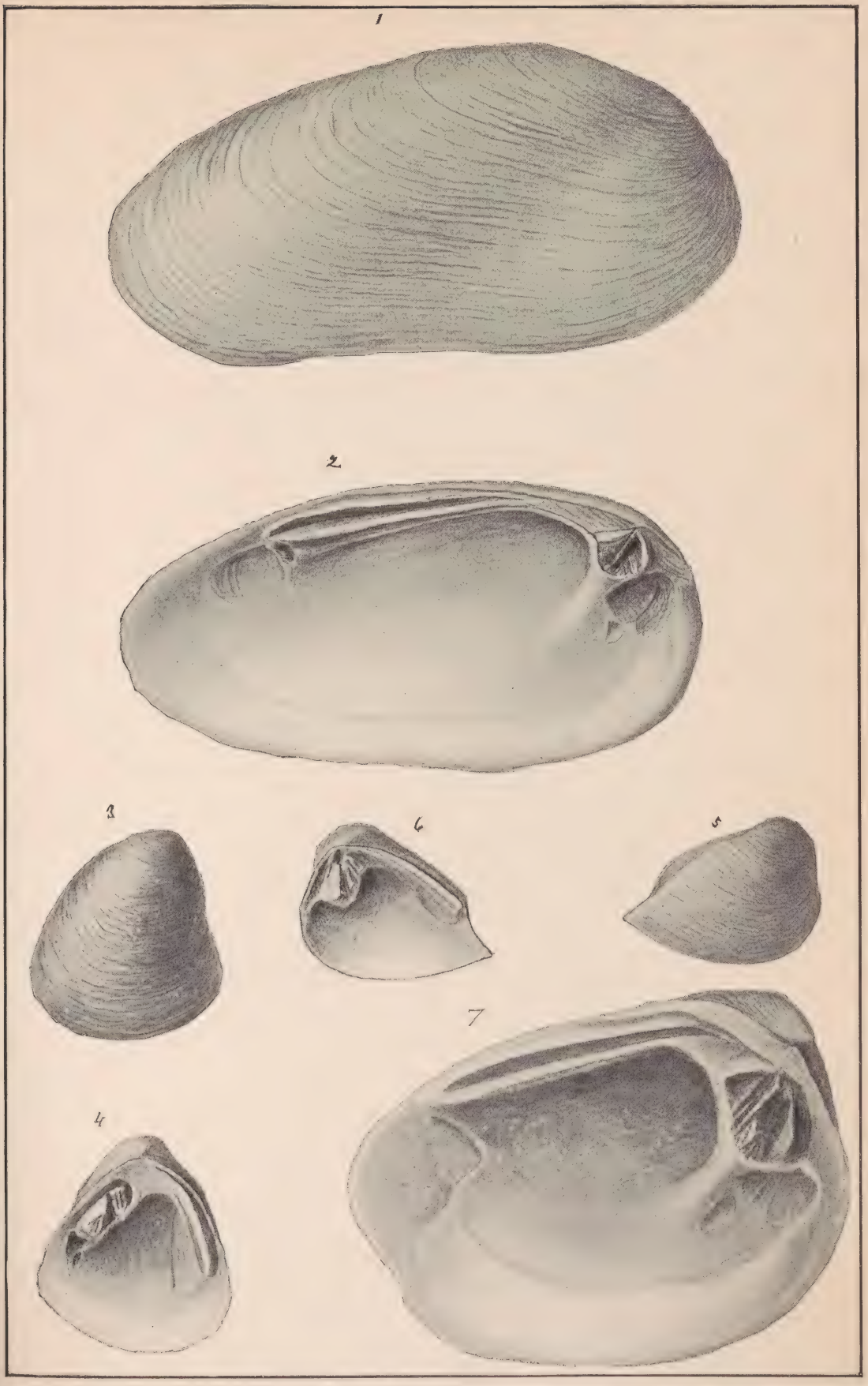
UNIO SUBTRIGONALIS n. sp. Page 626.

Fig. 5. Exterior view, natural size, of a very perfect valve.

Fig. 6. Interior view, natural size, of the same valve.

UNIO BIDESOPOIDES, n. sp. Page 624.

Fig. 7. Interior view, natural size, of a nearly perfect large valve. For exterior view see Plate XLI, Fig. 8.



New Fossil Unionidæ.

EXPLANATION OF PLATE XLI.

UNIO PYRAMIDATOIDES n. sp. Page 624.

Fig. 1. Exterior view, natural size, of a left valve showing the general features of a narrow form of the species, and the corrugated beak.

Fig. 2. Posterior view of the same, showing the flattened posterior side and ligamental area.

Fig. 3. Interior of a small valve of the species.

Fig. 4. Interior of a left valve showing the very heavy cardinal tooth and thick lateral tooth.

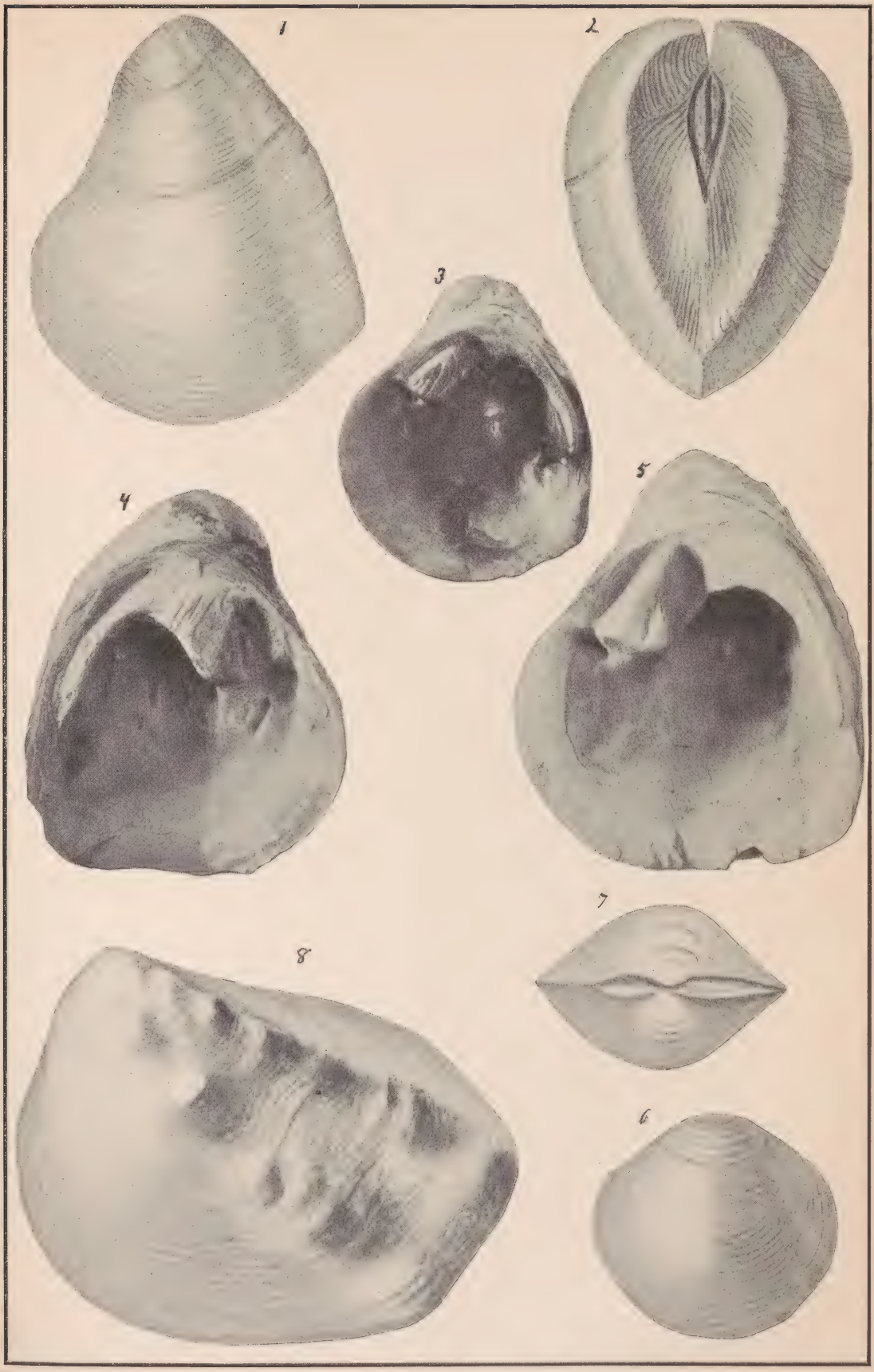
Fig. 5. Interior of a right valve of a larger individual showing the heavy cardinal tooth and the lateral with its corrugated ridge. This figure is of a somewhat broader form than the others, but not as broad as some. The last three figures are from photographs and do not show the features intended to be shown.

UNIO CORBICULOIDES n. sp. Page 627.

Figs. 6 and 7. Two views, natural size, of the only perfect individual of the species preserving the rotundity as well as all the markings of the species.

UNIO BIESOPOIDES n. sp. Page 624.

Fig. 8. View, natural size, of the exterior of a large entire valve, showing the double row of tubercles which characterize the species.



New Fossil Unionidæ.

EXPLANATION OF PLATE XLII.

UNIO LETSONI n. sp. Page 627.

Fig. 1. View of a young individual entirely covered by the corrugations of the beak portion and only showing two of the central lines of nodes.

Fig. 2. A somewhat older specimen showing three nodes on a line at the center. Perhaps only an abnormal feature.

Fig. 3. View of an almost adult valve showing all the prevailing features of the species, including the central line of nodes which allies it to *U. cornutus*.

Fig. 4. View of another and opposite valve showing four central nodes but much smaller in size; the third is only partially formed and marginal.

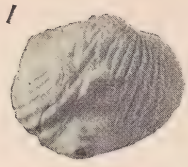
UNIO VERRUCOSIFORMIS *Whitf.*

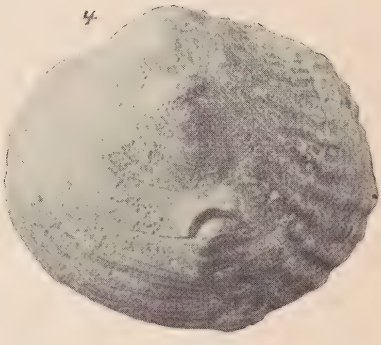
See Bull. Amer. Mus. Nat. Hist., Vol. XIX, p. 484, pl. xl, fig. 10.

Fig. 5. View of a medium-sized specimen, introduced to correct and explain the imperfect figure in the previous volume of this Bulletin.

Fig. 6. View of the inside of the same valve.

This species has proved to be quite abundant and fairly well preserved, whereas those in the collections of previous expeditions were very poor and scarce, and the one figured was the best obtained at that time. The shell is very rotund and the nodes and plications of the surface are distinct and often well shown.





New Fossil Unionidæ.

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Article XXVII. — THE NORTH AMERICAN SPECIES OF RHODITES AND THEIR GALLS.

By William Beutenmüller.

Plates XLIII–XLVII.

The object of the present paper is to bring together the known North American species belonging to the genus *Rhodites* in conjunction with what has been learned by personal observation and study.

The study of some western species has presented several difficulties owing to the want of sufficient material and field notes, and with the limited information at hand, I must frankly admit that it was not possible for me to bring this paper up to the proper standard of completeness, for the following reasons: The gall of *Rhodites politus* Ashmead is identical with that of *Rhodites nebulosus* Bassett, while the descriptions of the adults of these two species do not tally, and I consider it very likely that they are the same. *Rhodites multispinosus* Gillette, when we have more knowledge of this species, may possibly prove to be the same as *Rhodites tuberculator* Cockerell, and *Rhodites arefactus* Gillette the same as *Rhodites tumidus* Bassett; on the other hand, it may be possible that *R. multispinosus, R. tumidus, R. arefactus* and *R. tuberculator* are all one and the same species. But, owing to the want of conclusive evidence, I have preferred to consider these species as being distinct, rather than to unite them. I trust that the future students, located in the western States, will collect intelligently and look up the knotty points. The species of roses upon which the western species of *Rhodites* occur are practically unknown, and I would urge that all students of this genus, as well as of other gall-producing insects, pay particular attention to the identification of the host plants before publishing any notes or descriptions of new species, and to work out the imperfectly known food-habits of such species as are already known.

All the species of *Rhodites* known at present produce galls on different kinds of roses, and it seems that the genus is strictly confined to these plants. Twenty-nine species have been described, of which twenty are from North America, eight from Europe — four of which are also found in western Asia, and one species (*R. japonicus*) is known from Japan. *Rhodites rosæ* is common to Europe, Western Asia and North America, while the remaining species are confined to their respective countries.

The genus *Rhodites* was analytically described by Hartig in 1840 as follows: "Antennæ 15–16 jointed, maxillary palpi 4-jointed, labial palpi 2-jointed." The genus was erected for three European species, *R. rosæ*, *R. eglanteriæ* and *R. centifoliæ*. Osten Sacken in 1863 gave a general description of *Rhodites* and added certain characters not mentioned by Hartig. Osten Sacken states that he has never found more than 14 joints on the antennæ in both sexes. Mayr in 1881, and Dalla Torre and Kieffer in 1902 gave excellent technical descriptions of the genus *Rhodites*. Walsh in 1864 erected the genus *Tribalia* for *T. batatorum* which is now considered to be the same as *Rhodites radicum* O. S. In 1869 Förster erected the genus *Hololexis* for *Hololexis rufipes* (n. sp.), bred from monothalamous galls on wild rose. It is closely allied to *Rhodites eglanteriæ*, which he considered a true *Hololexis*. Dr. Gustav Mayr, in 1881, united *Hololexis* with *Rhodites* with which conclusion I fully concur, because Förster's description of *Hololexis* does not differ from that of *Rhodites*. In 1902 Kieffer erected the genus *Lytorhodites*, for the following North American species: *R. arefactus*, *R. fulgens*, *R. multispinosus*, *R. nebulosus*, *R. neglectus*, and *R. tuberculosus* O. S. The genus *Lytorhodites* differs from *Rhodites* only by having the radial cell at the margin more or less open and the scutellum without foveæ at the base. I consider these characters too trivial to be used for the erection of a new genus. Ashmead (Psyche, Vol. X, 1903, p. 210) erroneously states that the genus *Tribalia* has been rechristened by Abbé Kieffer under the name *Lytorhodites*. I have omitted *Rhodites globosus* Cockerell (Entomologist, Vol. XXIII, 1890, p. 75), because it was described from the gall only. I have seen the type in the United States National Museum and it appears to me to be nothing more than a small specimen of *Rhodites politus* Ashmead.

For specimens and information I am under obligation to Messrs. C. P. Gillette, Wm. H. Ashmead, A. D. Hopkins, Wm. M. Wheeler, E. B. Southwick, Wm. T. Davis, Mel. T. Cook, T. D. A. Cockerell, H. E. Summers, M. T. Thompson, A. L. Melander and C. T. Brues.

Synopsis of the Galls of Rhodites.

1.— Galls on the leaves.

Round, elongate or reniform woody galls covered with a white powder
Rhodites ignotus.

Shape similar to *ignotus*, brown or reddish, without white powder
Rhodites variabilis.

Lentil-shaped discs in the parenchyma of the leaf . { *Rhodites rosæfolii.* / *Rhodites lenticularis.*

Small, globular, hollow, with weak, minute spinules . { *Rhodites nebulosus.* / *Rhodites politus.*

Subovate, hollow, flat on top, with short blunt tubercles around the edge *Rhodites gracilis.*

2.— Galls on the branches or stems.

An agglomeration of hard cells around a branch, covered with long green moss-like filaments . . . . . *Rhodites rosæ.*

Elongate, woody swellings of the branch, tapering at each end *Rhodites dichlocerus.*

Globular galls covered with long sharp prickles, usually in clusters *Rhodites bicolor.*

Large, rounded, woody galls, without spines *R. tuberculator.*

Large, rounded galls, densely covered with spines . *Rhodites multispinosus.*

Small, rounded or elongate woody swellings, more or less in a row on the branch *Rhodites vernus.*

Rounded, elongate, puffy, soft swellings, single or several in a row *Rhodites fusiformans.*

Hard, rounded, woody, bud-like galls on a short stalk { *Rhodites arefactus.* / *Rhodites tumidus.*

Smooth, rounded, or reniform swellings surrounding a twig, abrupt at each end *Rhodites globuloides.*

Smooth, with two or more transverse ridges, rounded or elongate swellings abrupt at each end . . . . . *Rhodites neglectus.*

3.— Galls on the roots.

Rounded, warty, tomato-shaped or artichoke-tuber-like, attached on a short stalk . . . . . *Rhodites radicum.*

Similar to *R. radicum*, but with the top and sides deeply incised, rosette-like *Rhodites utahensis.*

Hard woody nodules, single or more or less coalescing . *Rhodites fulgens.*

Rhodites *Hartig.*

Cynips (part) Linné, Syst. Nat., ed. X, 1758, Vol. I, p. 553.

Diplolepis (part) Fourcroy, Ent. Paris, Vol. II, 1785, p. 391.

Rhodites Hartig, Zeitschr. für Ent. Germar, Vol. II, 1840, p. 186; Osten Sacken, Proc. Ent. Soc. Phil., Vol. II, 1863, p. 44; Mayr, 20 Jahrb. Comm. Oberrealsch., I, Bez. Wien., 1881, pp. 4, 10, 18; Provancher, Fauna Ent. Can., Vol. II, 1889, p. 159; Dalla Torre and Kieffer, Ins. Gen. Hymen. Fam. Cynip.,1902, pp. 44, 48 and 78; Ashmead, Psyche, Vol. X, 1903, p. 210.

Tribalia Walsh, Proc. Ent. Soc. Phil., Vol. II, 1864, p. 470; Kieffer, Bull. Soc. Hist. Nat. Metz, 2d ser., Vol. X, 1902, p. 96; Dalla Torre and Kieffer, Gen. Insect. Hymen. Cynip., 1902, pp. 47, 76; Ashmead, Psyche, Vol. X, 1903, p. 210.

Hololexis Förster, Verh. Zool.-Bot. Gesell. Wien, Vol. XIX, 1869, pp. 330 and 333; Mayr, 20 Jahrb. Comm. Oberrealsch. I, Bez., Wien, 1881, p. 18; Dalla Torre and Kieffer, Gen. Ins. Hymen. Fam. Cynip., 1902, p. 78.

Lytorhodites Kieffer, Bull. Soc. Hist. Nat. Metz, 2d ser., Vol. X, 1902, p. 96; Dalla Torre and Kieffer, Gen. Ins. Hymen. Fam. Cynip., 1902, pp. 44, 48, 79.

Head large, broader than the thorax; maxillary palpi 4-jointed, first long, almost twice as long as the second; second and third joints of equal size and rounded at one side; fourth joint as long as the first and conical, with a few setæ. Labial palpi 2-jointed, first joint elongate, parallel, second joint as long as the first, conical, with a number of setæ. Antennæ filiform, first and second joints globose or subglobose, second joint shorter than the first, third joint longer than the two preceding, fourth joint shorter than the third, remaining joints subequal.

Pronotum much narrowed in the middle. Parapsidal grooves more or less well marked. Base of scutellum with or without two small pits. Radial cell closed or somewhat open, not long. Tarsal claws simple. Abdomen smooth, shining. Hypopygium of female plow-shaped.

Type, Cynips rosæ Linn.

Rhodites rosæ (*Linn.*).

Cynips rosæ Linné, Syst. Nat., ed. X, 1758, p. 533.

Rhodites rosæ Hartig, Zeitschr. für Ent. Germar, Vol. II, 1840, p. 194; Osten Sacken, Proc. Ent. Soc. Phil., Vol. II, 1863, pp. 40, 45, 47; Walsh and Riley, Am. Ent., Vol. I, 1869, p. 166; Riley, Am. Ent., Vol. II, 1870, p. 213; Riley, and Fuller, Am. Ent., Vol. III, 1880, p. 298; Bassett, Proc. Am. Assoc. Adv. Sci., 1877, p. 305; Mayr, 20 Jahrb. Communal Oberrealsch., I, Bez. Wien, 1881, p. 18; Provanchier, Can. Nat., Vol. XII, 1881, p. 234; Weismann, Beitr. Kennt. Entwick. Ins., 1882, p. 3, pl. i, and ii, figs. 1–19; Ashmead, Tr. Am. Ent. Soc., Vol. XII, 1885, p. 293; *ibid.*, Vol. XIV, 1887, p. 133; Bull. 1, Col. Biol. Assoc., 1890, p. 38; Cockerell, Entomol., Vol. XXIII, 1890, p. 75; Beutenmüller, Bull. Am. Mus. Nat. Hist., Vol. IV, 1892, p. 248; Am. Mus. Journ., Vol. IV, 1904, p. 93, fig. 6; Ins. Galls Vicin. N. Y., 1904, p. 7, fig. 6; Bridwell, Trans. Kan. Ac. Sci., Vol. XVI, 1899, p. 203; Fyles, Rep. Ent. Soc. Ont., 1904 (1905), p. 95.

Male and female.— Head black with microscopic hairs, finely and regularly punctate in front, less punctate behind and on the vertex, jaws piceous. Antennæ wholly black. Thorax black with microscopic hairs, finely and regularly punctate, pleuræ finely rugoso-punctate with two polished areas. The two medio-dorsal

Figs. 1–4. *Rhodistes rosæ.* 1 and 2, wings; 3, underside of head, showing maxillary and labial palpi; 4, abdomen.

lines from the collar fine, narrow and reaching the middle of the thorax; the median groove from the scutellum extends forward to almost the ends of the anterior lines.

Parapsidal grooves narrow, fine, not smooth, and converging as they approach the scutellum. Scutellum finely rugoso-punctate. Abdomen red, posteriorly black, wholly black and small in the male. Legs red, femora infuscated at the base. Wings of female yellowish sub-hyaline, with a distinct radial cloud, extending beyond the veins of the cell; wings of male hyaline without the radial cloud. Length of male 2 to 2.50 mm.; of female 3 to 4 mm.

Gall (Plate XLIII, Figs. 5, 6).— Polythalamous. Composed of an agglomeration of hard cells around a branch, and it is densely covered with long, green filaments forming a moss-like mass. It measures from 25 to about 50 mm. in diameter. Occurs on the terminal twigs of sweet briar (*Rosa rubiginosa* and *Rosa blanda*).

Habitat: Europe; Western Asia; Canada; Massachusetts; Rhode Island; (New England States); New York; New Jersey; Pennsylvania; Washington, D. C.; (Middle States); Kansas; Colorado.

The gall is quite common locally and is fully grown in September. When young it is sometimes bright scarlet red. In Europe it is known as the beduguar of the rose. The adults emerge in May and June. An extensive bibliography of this species may be found in Dalla Torre's Catalogus Hymenoptorum, Vol. II, 1893, pp. 128–129. Mr. M. T. Thompson has taken the galls on the European *Rosa rugosus* and *Rosa cinnamoea* found in cultivation in Massachusetts. In Europe the galls are found on ten species of roses. The type of *R. rosæ* is probably lost.

Rhodites bicolor (*Harr.*).

Cynips bicolor Harris, Rep. Ins. Mass. Inj. Veget., 1841, p. 399; Treat. Ins. New Eng. Inj. Veget., 2d ed., 1852, p. 435; Treat. Ins. Inj. Veget. 3d ed., 1862, p. 548; *ibid.*, Flint ed., 1862, p. 548; *ibid.*, 1863; Osten Sacken, Ent. Zeit. Stettin, Vol. XXII, 1861, p. 415.

Rhodites bicolor Osten Sacken, Proc. Ent. Soc. Phil., Vol. II, 1863, pp. 43, 45, 48, Riley, Am. Ent., Vol. II, 1870, p. 309, fig. 192; Mayr, 20 Jahrb. Communal Oberrealsch., I, Bez. Wien, 1881, p. 18; Ashmead, Trans. Am. Ent. Soc. Vol. XII, 1885, p. 293; *ibid.*, Vol. XIV, 1887, p. 133; Bull. 1, Col. Biol. Assoc., 1890, p. 38; Provancher, Fauna Ent. Canada, Vol. II, 1889, p. 160; Cockerell, Entomol., Vol. XXIII, 1890, p. 75, Gillette, Ent. News, Vol. III, 1892, p. 246; Beutenmüller, Bull. Am. Mus. Nat. Hist., Vol. IV, 1892, p. 246, pl. ix, fig. 1; Am. Mus. Journ., Vol. IV, 1904, p. 92, fig. 1; Ins. Galls Vicin. N. Y., 1904, p. 6, fig. 1; Bridwell, Trans. Kan. Ac. Sc., Vol. XVI, 1899, p. 203; Cook, 29th Rep. Dept. Geol. & Nat. Hist. Res. Ind. 1904 (1905), p. 816, fig. 10.

Rhodites spinosellus Cockerell, Entomol., Vol. XXIII, 1890, p. 75; Ent. Student, Vol. I, 1900, p. 10.

Rhodites tumidus Townsend, Psyche, Vol. VII, 1895, p. 272 (in error); *ibid.*, p. 307 (correction).

Male and female.— Head black with very short white hairs, front roughly punctate, finely punctate behind, jaws rufous. Antennæ 14-jointed, black, first and second joints piceous or almost black in the female, wholly black in the male. Thorax prominently rugoso-punctate, subopaque; two smooth, parallel, shining lines

from the collar almost extending to the middle of the thorax; median groove from the scutellum long, distinct and extending forward to almost the ends of the anterior lines. Parapsidal grooves rather deep, distinct, converging as they reach the scutellum, where they are widely separated; outside of these grooves there is sometimes a smooth line on each side; pleuræ rugoso-punctate with the usually shining area hardly apparent. Scutellum very rugose and large. Abdomen red in the female, black or piceous in the male. Legs yellowish red with very short hairs. Wings subhyaline, yellowish brown in the female; brownish cloud on radial area distinct, veins brown; in the male the wings are hyaline without the yellowish tint and radial cloud. Length of male 2.50 to 3 mm.; of female 3.25 to 4.50 mm.

Gall (Plate XLIII, Figs. 1–4).— Monothalamous. Spherical, covered with many prickly spines as long or longer, or shorter, than the diameter of the gall. Internally it is hollow with the wall about 1 to 2 mm. thick, but in specimens infested by guest-flies, it is almost entirely pithy inside. Yellowish green, sometimes tinged with red. Soft and fleshy in summer, woody and brown in winter. It is found singly or in clusters of from two to ten or more upon twigs of different kinds of wild roses (*Rosa carolina, R. blanda, R. humilis, R. pisocarpa*? and probably other species). It measures from 5 to 12 mm. in diameter.

Habitat: Canada; Maine; Massachusetts; Rhode Island; Connecticut; New York; New Jersey; Pennsylvania; Washington, D. C.; North Carolina; Mississippi; Wisconsin; Indiana; Colorado; Washington; New Mexico.

The gall is quite common in the latitude of New York, and reaches maturity in autumn. The number of species of wild roses upon which the galls are formed will undoubtedly increase after a careful study of its food-habits. Harris's types are probably in the Boston Society of Natural History.

Rhodites ignotus *O. S.*

Rhodites ignota Osten Sacken, Proc. Ent. Soc. Phil., Vol. II, 1863, pp. 44, 45, 49; Beutenmüller, Bull. Am. Mus. Nat. Hist., Vol. IV, 1892, p. 246, pl. ix, fig. 2; Am. Mus. Journ., Vol. IV, 1904, p. 94, fig. 7; Ins. Galls Vicin. N. Y., 1904, p. 8, fig. 7.

Rhodites carolina Ashmead, Trans. Am. Ent. Soc., Vol. XIV, 1887. pp. 133, 148.

Male and female.— Head black, with microscopic hairs, rugosely punctate in front, finely punctate posteriorly. Antennæ 14-jointed, black, first and second joints rufous or piceous in the female, wholly black or piceous in the male. Thorax evenly rugoso-punctate, anterior lines, median and parapsidal grooves present, but very indistinct and hardly visible. Pleuræ rugoso-punctate, without the usual shining area. Scutellum rugoso-punctate. Abdomen red in the female, black and small in the male. Legs red in both sexes. Wings subhyaline, yellowish; veins dark brown with a distinct brown cloud on the radial veins with the disc hyaline. Wings of male hyaline with slight traces of the brown cloud on the radial veins. Length of male 1.50 to 3 mm.; of female 2.50 to 3.50 mm.

Gall (Plate XLIII, Figs. 7–10).— Monothalamous. Very variable in shape and size. Spherical, irregularly rounded, reniform, single or more or less confluent or two or three entirely coalesce thus forming an elongated mass of irregular shape. Clay brown, covered with a white farinaceous powder. Hard, woody, containing

a rather large larval cell in the single gall and two or more cells in the coalescent ones. They are formed on the terminal twigs, leaves or leaf-stalks, and as a rule are found in a cluster of from two to twenty. Measures from 4 to 15 mm. in diameter. On wild rose (*Rosa blanda, R. nitida* and *R. carolina*).

Habitat: Massachusetts; Connecticut; New York; New Jersey; Pennsylvania; Washington, D. C.; Black Mountains, North Carolina; Iowa.

The types of *R. ignotus* are in the Museum of Comparative Zoölogy, Cambridge, Mass., and one type of the gall in the American Museum of Natural History.

Rhodites variabilis *Bass.*

Rhodites variabilis Bassett, Trans. Am. Ent. Soc., Vol. XVII, 1890, p. 61; Cockerell, Ent. Student, Vol. I, 1900, p. 10.

Male and female.— Head large, broader than the thorax, finely punctate in front and on the vertex, and with short microscopic hairs, black, mandibles ferruginous. Antennæ 14-jointed, longer in the male than in the female, black in the male, with the first and second joints in the female ferruginous; all joints with very short hairs. Thorax black, finely rugose with microscopic hairs, two parallel, smooth median lines from the collar to nearly the middle of the thorax and a very short median line from the scutellum; parapsidal grooves not deep, finely punctate and converging as they approach the scutellum. Scutellum rugose with microscopic hairs, somewhat depressed at its junction with the mesonotum. Abdomen yellowish brown and somewhat darker toward the end in the female, small and blackish in the male. Legs yellowish brown in both sexes with very minute hairs. Wings hyaline with dark brown veins; radial area finely clouded with brown in the male, slightly more so in the female. Length of female 2.25 to 3 mm.; of male 2 to 2.25 mm.

Gall (Plate XLVI, Figs. 5–9).— Monothalamous. Variable in size and shape. Spherical, irregularly rounded, somewhat ovate or reniform, through coalescence of two or more galls. Russet brown sometimes tinged with red. Internally they are pith-like with a large larval cell in the center. In the larger galls where two or more are confluent there are several larval cells. The galls occur usually in a cluster of from two to ten on the small terminal twigs, or are attached to the leaf stems, while others grow on fully developed leaves of a wild rose (*Rosa* sp.). The rounded forms measure from about 5 to 15 mm. in diameter and the elongated forms from about 15 to 24 mm.

Habitat: Boulder, Colorado (Mrs. W. P. Cockerell); Southern Utah (A. H. Siler); Cedar Mountains, Idaho; Wenachee, Washington; Paris, Texas; Wyoming (Bruner).

This species is closely allied to *Rhodites ignotus* both in the adults and the galls. The types are in the collections of the American Entomological Society and the American Museum of Natural History.

Rhodites vernus *O. S.*

Cynips (*Rhodites* ?) *tuberculosa* Osten Sacken, Ent. Zeit. Stettin, Vol. XXII, 1861, p. 415.

Rhodites verna Osten Sacken, Proc. Ent. Soc. Phil., Vol. II, 1863, pp. 41, 45, 47; Mayr, 20 Jahrb. Communal Oberrealsch., I, Bez. Wien, 1881, p. 18; Ashmead, Trans. Am. Ent. Soc. Vol. XII, 1885, p. 293; *ibid.*, Vol. XIV, 1887, p. 133; Beutenmüller, Bull. Am. Mus. Nat. Hist., Vol. IV, 1892, p. 248, pl. ix, fig. 6; Journ. Am. Mus., Vol. IV, 1904, p. 93, fig. 5; Insect Galls Vic. N. Y., 1904, p. 7, fig. 5.

Lytorhodites tuberculosus Kieffer, Bull. Soc. Nat. Hist. Metz, 2d Ser. Vol. X, 1902, p. 97.

Male and female.— Head and antennæ black, mandibles reddish. Thorax black, finely, not densely sculptured, somewhat shining, pubescent. Parapsidal grooves, touching the humeri, moderately deep. Intermediate grooves generally appear as smooth lines, unless viewed obliquely. Scutellum rugose on the sides, more smooth in the middle. Abdomen of male black, of female red, fringed with pale yellowish hairs on the hind borders. Tip of sheath of female brown. Feet red, coxæ black, base of femora in the female black. Wings of male hyaline, of female tinged with brown and with a more or less distinct cloud on the radial area and its surroundings. In both sexes the second transverse vein has no projection within the radial area and is arcuate. Areolet moderately large in the male and larger in the female. Length of male 2.50 mm.; of female 3.75.

Gall (Plate XLIV, Fig. 1).— Polythalamous. Oblong or rounded swellings on small branches. Sometimes there is a series of three or more swellings attached to each other. Reddish, hard and woody, with several cells inside. Length about ½ inch. On the stem of wild rose (*Rosa blanda*).

Habitat: New York; Washington, D. C.

The species, briefly described as *Cynips* (*Rhodites*?) *tuberculosa* by the late Baron von Osten Sacken, is probably the same as his *Rhodites vernus*. The description of the gall of *tuberculosa* agrees with that of *R. vernus*, but the description of the gall-fly of *tuberculosa* is too brief for recognition. Osten Sacken's description of *Cynips* (*Rhodites*?) *tuberculosa* is as follows: "Rundliche oder längliche, kaum einen halben zoll lange anschwellungen an den zweigen: *Cynips* (*Rhodites*?) *tuberculosa* n. sp. ♀, 14-gliedrige antennen; ♂ scheinbar auch 14-gliedrig, da das letzte, 15-glied, sehr kurz und undeutlich ist. Ich wage kaum diese art für *Rhodites* zu halten, da die radialzelle zwar einen verdickten, haarigen vorderrand hat, doch aber nicht für geschlossen angesehen werden darf." The following is a translation of the above. Rounded or elongate swellings hardly one half inch in length on the twigs (of rose); *Cynips* (*Rhodites*?) *tuberculosa* n. sp. ♀, antennæ 14-jointed; ♂ apparently also 14-jointed, as the last, 15th joint is very short and indistinct. I hardly venture to consider this species as a *Rhodites*, because the radial cell has a thickened, hairy costal margin, but it cannot be regarded as being closed. The types of *R. vernus* are in the Museum of Comparative Zoölogy, Cambridge, Mass., and one type of the gall is in the American Museum of Natural History, from which the figure (Plate XLIV, Fig. 1) was made.

Rhodites dichlocerus (*Harr.*).

Cynips dichlocerus Harris, Rep. Ins. Mass. Inj. Veget., 1841, p. 399; Treat. Ins. New Engl. Inj. Veget., 2d ed., 1852, p. 345; Treat Ins. Inj. Veget., 3d ed., 1862, p. 549, pl. viii, figs. 6, 7, 8; *ibid.*, Flint ed., 1862, p. 549, pl. viii, figs. 6, 7, 8; *ibid.*, 1863.

Cynips dichloceros Osten Sacken, Ent. Zeit. Stettin, Vol. XXII, 1861, p. 415.

Rhodites dichlocerus Osten Sacken, Proc. Ent. Soc. Phil., Vol. II, 1863, pp. 41, 45, 46; Glover, Ill. N. Am. Ent., 1878, pl. viii, fig. 18; Mayr, 20 Jahrb. Communal Oberrealsch, I, Bez. Wien, 1881, p. 18. Ashmead, Trans. Am. Ent. Soc., Vol. XII, 1885, p. 263; *ibid.*, Vol. XIV, 1887, pp. 133, 148; Bull, 1, Col. Biol. Assoc., 1890, p. 38; Beutenmüller, Bull. Am. Mus. Nat. Hist., Vol. IV, p. 247, pl. ix, fig. 5; Am. Mus. Journ., Vol. IV, 1904, p. 93, fig. 4. Ins. Galls Vicin. N. Y., 1904, p. 7, fig. 4; Cook, Proc. Ind. Acad. Sci., 1904, p. 225; 29th Rep. Dept. Geol. & Nat. Hist. Res. Ind., 1904 (1905), p. 819, fig. 3.

Cynips (*Rhodites*) *dichlocerus* Glover, Rep. U. S. Comm. Agricul., 1877 (1878), p. 95, pl. ii, fig. 21.

Rhodites spinosa Ashmead, Trans. Am. Ent. Soc., Vol. XIV, 1887, pp. 34, 148; Webster, Can. Ent., Vol. XXVII, 1895, p. 68.

Female.— Head yellowish brown, eyes black, finely and regularly punctate in front, less punctate posteriorly. Antennæ 14-jointed, first, second and third joints reddish brown, remaining joints black. Thorax, abdomen and legs brown, sheath of ovipositor black. Thorax regularly and evenly punctate, anterior parallel lines almost extending to the middle of the thorax; median groove from the scutellum extending well forward to nearly the ends of the anterior lines. Parapsidal grooves well developed and almost parallel, widely separated at the scutellum. Pleuræ finely and regularly rugoso-punctate without any shining area. Legs yellowish red, claws black. Wings subhyaline, yellowish, veins brown and no radial cloud. Length 3 to 4 mm.

Male.— Head, antennæ and thorax piceous black, sometimes rufo-piceous. Abdomen yellowish red basally, otherwise black. Legs yellowish red, claws black and sometimes also the last tarsal joint. Pleuræ with a finely punctate shining area which is sometimes rufous. Wings hyaline and without radial cloud, veins brown. Length 2 to 2.50 mm.

Gall (Plate XLIV, Figs. 9–14). — Polythalamous. Elongate, subfusiform, gradually tapering at both ends. Smooth or more or less densely covered with short spiny prickles like the gall of *Rhodites multispinosus*. Red, hard and woody with numerous cells internally. Measures from 14–54 mm. in length and from 7 to 18 mm. in width. Occurs on the branches and twigs of wild roses (*Rosa carolina*, *R. humilis*, *R. canina* and *R. nitida*).

Habitat: Massachusetts; Rhode Island; Connecticut; New York; New Jersey; Pennsylvania; Washington, D. C.; Delaware; North Carolina; Indiana; Ohio; Colorado.

The flies bred by me from the spiny galls named *Rhodites spinosus* by Dr. Ashmead are identical with the ones bred from the smooth gall of *Rhodites dichlocerus*. Harris's types are probably in the Boston Society of Natural History.

Rhodites globuloides sp. nov.

Osten Sacken, Proc. Ent, Soc. Phil., Vol. II, 1863, p. 62, (unnamed).

Rhodites ignota Ashmead, Trans. Am. Ent. Soc., Vol. XII, 1885, p. 293; *ibid.*, Vol. XIV, 1887, pp. 133, 148 ; Bull. 1, Col. Biol. Assoc., 1890, p. 38; Gillette, Ent. News, Vol. III, 1892, p. 246.

Rhodites globulus Beutenmüller, Bull. Am. Mus. Nat. Hist., Vol. IV, 1892, p. 247, pl. ix, fig. 4; Am. Mus. Journ., Vol. IV, 1904, p. 93, fig. 3; Ins. Galls Vicin. N. Y., 1904, p. 7, fig. 3; Cook, 29th Rep. Dept. Geol. & Nat. Hist. Res. Ind., 1904 (1905), p. 818, fig. 12.

Female.— Head black, finely and evenly punctate, with microscopic hairs. Antennæ black, first and second joints rufous, third joint piceous. Thorax evenly rugose, subopaque. Anterior lines wanting. Median groove from the scutellum scarcely visible. Parapsidal grooves very obsolete, slightly evident posteriorly. Pleuræ rugose, subopaque, somewhat shining beneath the wings. Scutellum very rugose, black. Abdomen and legs rufous. Wings subhyaline, yellowish; radial cell heavily clouded with brown on the veins with the disc hyaline, the brown shade extends beyond the veins. Length 3 mm.

Gall (Plate XLIV, Figs. 2–6). — Polythalamous. Smooth, rounded or oblong, arising at each end abruptly from the branch. Green and fleshy when fresh; and brown, soft and corky when dry. Measures from about 10 to about 22 mm. in width and 35 mm. in length.

Habitat: Massachusetts; Rhode Island; New York; New Jersey; Connecticut; Indiana; North Carolina; Florida; Michigan.

Described from a single female gall-fly. The type of the adult and galls are in the American Museum of Natural History.

The insect described by me as *Rhodites globulus* is a guest-fly, synonymous with *Periclistis pirata* O. S., consequently a new name must be used for the true gall maker. I propose for it *Rhodites globuloides*. Dr. William Ashmead erroneously refers to this species as *Rhodites ignota* in his various papers on Cynipidæ. The gall of *Rhodites globuloides* occurs on the branches of *Rosa carolina* and is quite common locally in certain localities. I have collected over a hundred specimens of the galls from which I reared hundreds of its guest-fly *Periclistis pirata*, but only a single specimen of the true gall maker.

Rhodites neglectus *Gill.*

Rhodites neglecta Gillette, Can. Ent., Vol. XXVI, 1894, p. 158; Cockerell, Ent. Student, Vol. I, 1900, p. 10.

Lytorhodites neglectus Kieffer, Bull. Soc. Nat. Hist. Metz, 2d Ser., Vol. X, 1902, p. 97;

Female.— "Head black, except a little rufous upon the vertex and clypeus; face rather coarsely rugose, vertex and occiput finely rugose; antennæ entirely black, 14-jointed. Thorax entirely black, parapsidal grooves well defined and broadened anteriorly, median groove traceable but a short distance from the scutellum. Surface of the mesothorax shining, but under a low power of the microscope is seen to

have a fine network of impressed lines and numerous shallow punctures over the entire surface; from each puncture arises a small yellowish hair. Scutellum black, slightly rufous on the middle of the disc, coarsely rugose about the margin, less coarsely on the central portion. Pleuræ and mesothorax black and coarsely to finely rugose, most finely on the central portion of the mesopleuræ beneath the fore wings. Abdomen black, except sides of second segment near the base, the seventh segment and the anterior portion of the venter. All the surface of the abdomen is covered with a network of microscopic impressed lines. Wings slightly smoky, radial area not at all closed along the costal margin. Feet rufous, except coxæ, which are blackish. Length 2.50 to 3 mm.

"Described from two bred females.

"*Male.*— Except feet, entirely black; length 2.50 mm.; otherwise like female" (*C. P. Gillette*).

Gall. (Plate XLIV, Figs. 7, 8).— Polythalamous. Rounded or oval, usually longer than broad. Abrupt at each end and sometimes depressed at each side. Externally it is smooth with one or more ridges which do not encircle the gall. Internally it is corky and contains numerous larval cells. Length, 14 to 18 mm.; width 11 to 15 mm. Occurs on the branches of wild rose (*Rosa* sp.).

Habitat: Manitou, and Fort Collins, Colorado (Gillette); Colorado Springs, Colorado (Cockerell); Pullman, Washington (Agricul. College).

A single female and gall of this species I received from Professor T. D. A. Cockerell. The gall agrees exactly with the type of *Rhodites neglectus*, but the flies differ slightly from the original description by Professor Gillette. In my specimen the anterior parallel lines are narrow, distinct and not punctate and almost reach the middle of the thorax. These lines were not mentioned by Professor Gillette, otherwise my specimen agrees with his *R. neglectus*, except that it wants the rufous mark on the scutellum. The types are with Prof. C. P. Gillette.

Rhodites tumidus *Bass.*

Rhodites tumidus Bassett, Trans. Am. Ent. Soc., Vol. XVII, 1890, p. 60; Cockerell, Ent. Student, Vol. I, 1900, p. 10.

Female.— Head black, evenly and rugosely punctate in front. Antennæ in the female black, first and second joints rufous or wholly black; in the male always black. Thorax black finely and rugosely punctate, rather dull; anterior parallel lines short, median groove from the scutellum extending almost to the middle of the thorax. Parapsidal grooves distinct, fine, punctate and well separated at the scutellum. Pleuræ rugose with a finely punctate shining area. Scutellum rugose, black or with a rufous patch. Abdomen dark reddish brown in the female sometimes approaching black, wholly black or sometimes dark rufous in the male. Legs reddish brown. Wings with a yellowish tinge in the female with the veins of the radial area clouded with brown. Areolet large; veins brown; the wings of the male are without the yellowish tinge and the cloud on the radial veins, and the areolet is smaller. Length of male 1.50 to 3 mm.; of female 2.50 to 3.25 mm.

Gall (Plate XLV, Figs. 5–7).— Polythalamous. Red or reddish brown. Glob-

ular or irregularly rounded, smooth when fresh, but wrinkled when dry. Terminal part somewhat of form of a half-opened rose or miniature cabbage, the lines on the surface being the outlines of the leaves. Upper half of some specimens have a thin white papery epidermis, which is usually torn and curled. Internally the gall is of a soft, cellular pithy consistence, with traces of the stems of the leaves. They grow on the end of a woody stem, or are in some cases nearly sessile. Measures from 16 to 30 mm. in diameter.

Habitat: Southern Utah.

One male and two female type specimens of the gall-flies and several galls are in the collection of the American Museum of Natural History. The figures of the galls on plate XLV, (Figs. 5, 6, 7), were made from the types. Bassett's types are in the collections of the American Entomological Society and the American Museum of Natural History.

Rhodites arefactus *Gill.*

Rhodites arefactus Gillette, Can. Ent., Vol. XXVI, 1894, p. 157; Cockerell, Ent. Student, Vol. I, 1900, p. 10.

Rhodites similis Ashmead, Proc. U. S. Nat. Mus., Vol. XIX, 1897, p. 136; Cockerell, Ent. Student, Vol. I, 1900, p. 10.

Lytorhodites arefactus Kieffer, Bull. Soc. Nat. Hist. Metz, 2d Ser., Vol. X, 1902, p. 97.

R. arefactus, female.— "General color cinnamon-rufous; head entirely rufous, except a blackish area between either compound eye and the mouth; under a power of sixty diameters the lower face appears rather coarsely wrinkled, the wrinkles converging towards the mouth, the upper face, vertex and occiput very finely rugose, the face sparsely set with a short gray pubescence; antennæ short, the first (two) joints, and sometimes the basal third, rufous, remaining joints black; number of joints, fourteen. Thorax rufous above, with a black suture separating the mesothorax and scutellum, parapsidal grooves entire, broad, moderately deep, well separated at the scutellum, and with numerous elevated lines crossing them; median groove distinct and extending well forward. The surface of the thorax is finely rugose, and, in the proper light, shows numerous punctures, each puncture bearing a short yellowish hair. Scutellum coarsely wrinkled near the margin, and less coarsely wrinkled on the central portion, which is considerably elevated, transverse groove at base, color rufous. Mesopleura, except spot just beneath the wings, rufous, sutures, metathorax and sternum black or blackish; entire pleura rugose. Abdomen rufous, with venter and posterior half of dorsum blackish, all abdominal segments covered with a microscopic network of impressed lines, most prominent on the terminal segments. Wings but little smoky, radial area not at all closed along the costal margin, areolet distinct and rather small. Feet, including the coxæ, entirely rufous, the claws only being black. Length, from 3.25 to 4.50 mm.

"*Male.*— 3 to 3.50 mm. in length, black, feet more reddish in color than in the female, bases of the coxæ black, antennæ black throughout; otherwise like the female.

"Described from forty-two bred specimens. There is one male among those reared that has the rufous markings of the female on head, antennæ and thorax" (*C. P. Gillette*).

Gall (Plate XLV, Fig. 1).— "Dense, corky enlargements of small shoots, usually close to the stem from which the shoots arise, and the shoot is usually dead beyond the gall when the latter is mature. The galls are irregular in shape, vary from one half to seven-eighths of an inch in diameter, and are polythalamous. The surface is of a rusty color, is finely wrinkled and reminds one of a dried fruit. The surface appears dry and hard, but it is easily dented with the finger-nail and is always free from spines.

"Described from eighteen galls collected in March in the vicinity of Fort Collins, Colorado. Galls brought into the laboratory March 7th began giving flies March 23d " (*C. P. Gillette*).

R. similis, female.— In stature and color, this species is very near *dichlocerus* Harr., but the surface of the thorax is much smoother, shining, the head and the lateral lobes of the mesothorax are darker, almost black, the median and parapsidal grooves more distinct, broader, the disk of the mesopleura smoother, veins darker, while the vein at base of marginal cell is arcuate.

"The male is entirely black, except the basal antennal joints, spots on vertex above base of antennæ, and the legs, which are red, the middle and posterior coxæ being black basally.

"*Habitat*: Point of Rocks, Wyoming (Bruner)."

Gall (Plate XLV, Figs. 2–4).— "An irregular, rounded, brown or brownish yellow, pithy gall on the smaller stems of an unknown wild rose. They vary greatly in size and shape, from a small pea-like form to a more or less globular or oblong shape, some of them being an inch or more in length. There is no consistency in their shape; some are perfectly round, oblong, or of various irregular shapes" (*W. H. Ashmead*).

The above are copies of the original descriptions of the gall-flies and galls of *Rhodites arefactus* Gillette and *Rhodites similis* Ashmead. One male and one female, type, with a specimen of the gall of *Rhodites arefactus* were kindly sent to me by Prof. C. P. Gillette and two female cotypes, together with several galls of *Rhodites similis* were given to me by Dr. William H. Ashmead. The flies of *Rhodites similis* are the same as *Rhodites arefactus*. The galls of both these are also exactly similar. Figure 1, Plate XLV, was made from the type of the gall of *R. arefactus* and figures 2, 3, 4 (Plate XLV) were made from cotypes of *R. similis*. Figure 13 (Plate XLV), was received from California by Dr. Mel. T. Cook. I am of the opinion that *R. arefactus* will ultimately prove to be a color variety of *R. tumidus*. The types of *R. arefactus* are with Prof. C. P. Gillette, and one male and female with gall are in the collection of the American Museum of Natural History. Ashmead's types of *R. similis* are in the United States National Museum.

Rhodites tuberculator *Ckll.*

Rhodites tuberculator Cockerell, West Am. Sci., Vol. IV, 1888, p. 60; Entomol., Vol. XXIII, 1890, p. 75; Ent. Student, Vol. I, 1900, p. 10; Ashmead, Bull. 1, Col. Biol. Assoc., 1890, p. 38; Gillette, Ent. News, Vol. III, 1892, p. 247.

Female.— Head piceous in front with a rufous mark along the middle, sides and posterior portion piceous, vertex rufous; finely punctate. Antennæ black, first three joints rufous. Thorax rufo-piceous finely and sparsely punctate. Anterior lines very fine and scarcely visible. Parapsidal grooves distinct, moderately deep and widely separated at the scutellum. Median groove from the scutellum extending well forward, distinct but not prominent. Pleuræ piceous rugoso-punctate, with a shining black or rufous area beneath the base of the wings. Scutellum rugose, with a rufous spot. Abdomen yellowish, sometimes blackish above and at the tip. Legs rufous. Wing yellowish hyaline and without radial cloud. Length 3 mm.

Male.— Entirely black. Legs rufous. Length, 1.50 to 2.75 mm.

Gall (Plate XLV, Figs, 8, 9, 10).— Polythalamous. Spherical or elongate rounded. Surface shining or corrugated. Reddish yellow varying to pink and dull purplish. It grows surrounding a twig of a species of wild rose, so that it projects beyond and from the middle of the gall at each end. Sometimes it grows at the tip of a twig; the apex of the gall is then bud-like. Internally it is of a soft, white, pithy, cellular structure, containing many larval cells. Measures from about 25 to 38 mm. in diameter.

Habitat: West Cliff, Custer Co., Colorado (T. D. A. Cockerell); Utah (H. K. Morrison); Colorado (Gillette).

The figures (Plate XLV, Figs. 8–10) were made from specimens given to me by Prof. A. D. Hopkins. The types are supposed to be in the United States National Museum.

Rhodites multispinosus *Gill.*

Rhodites spinosissima Gillette, Bull. 7, Iowa, Agricul. Exp. Sta., 1889, p. 244, fig. 28 (name preoccupied).

Rhodites multispinosa Gillette, Ent. Amer., Vol. VI, 1890, p. 25, fig. 2; Proc. Iowa Acad. Sci., Vol. I, pl. ii, 1892, p. 110.

Lytorhodites multispinosus Kieffer, Bull. Soc. Nat. Hist. Metz, Ser. 2, Vol. X, 1902, p. 97.

"*Female.*— Head rufous, almost black beneath the eyes, finely rugose and covered with gray pubescence. A little black shading on the vertex surrounds the ocelli. Thorax rufous, punctured, parapsidal grooves broad, but not deep, and extend to the scutellum. Two naked parallel lines extend a little more than one third the distance from the collar to the scutellum between the parapsidal grooves. Thorax, like the head, thinly set with short hairs. Scutellum more coarsely rugose than the other parts of the thorax and without foveæ. Abdomen dark rufous, polished and very finely rugose. Ventral valve black. Antennæ 14-jointed, the first three joints rufous, the others black. Wings subhyaline, areolet large, marginal cell open. Length 4.3 mm.

"*Male.*— Entirely black, except the legs and a little rufous coloring about the ocelli. Legs reddish brown. Antennæ 14-jointed, and nearly or quite as long as the body. Length 3.5 mm. Otherwise like the female."

"*Gall* (Plates XLV, Figs. 11, 12 and XLVI, Fig. 1).—Round, knot-like, hard and woody, especially so when dry. Reddish brown and more or less densely covered

with rather sharp, stout spines. It measures from about 20 to 32 mm. in diameter. Occurs on the terminal stems or shoots of wild roses (*Rosa* sp.)." (*C. P. Gillette.*)

Habitat: Minnesota (Gillette); Milwaukee, Wisconsin; Pullman, Washington; Ontario, Canada (Brodie).

The types of the gall-flies, one male and two females, and one gall of *Rhodites multispinosus*, are in the collection of the Agricultural College at Ames, Iowa, and were kindly sent to me for examination by Professor Henry E. Summers. In the adults the parapsidal grooves are distinct and widely separated at the scutellum. The median groove from the scutellum is distinct and extends forward to almost the ends of the anterior lines. The thorax is finely and evenly punctate and the scutellum is rugose. The wings of the female are yellowish hyaline and without a dark radial cloud. The wings of the male are somewhat paler and the abdomen at the extreme base is rufous. Otherwise the specimens agree with Prof. Gillette's description given above.

A number of gall-flies which were bred from a gall exactly similar to that of *Rhodites multispinosus* were sent to me by Mr. A. L. Melander, from Pullman, Washington. In these specimens the females vary in color from rufous to almost entirely black, while the males are the same as the type of *R. multispinosus*, proving that the female gall-flies of this species are subject to considerable variation. The figure (Plate XLVI, Fig. 1) was made from the type gall of *R. multispinosus* and the figures (Plate XLV, Figs. 11, 12) were made from specimens collected at Milwaukee, Wisconsin, and sent to me by Mr. C. T. Brues. I am of the opinion that *R. multispinosus* may prove to be the same as *R. tuberculator* Cockerell.

Rhodites fusiformans *Ashm.*

Rhodites fusiformans Ashmead, Bull. 1, Col. Biol. Assoc., 1890, pp. 14, 38; Cockerell, Entomol., Vol. XXIII, 1890, p. 75; Ent. Student, Vol. I, 1900, p. 10; Gillette, Ent. News, Vol. III, 1892, p. 246.

Male and female.— Head black with microscopic hairs, coarsely-punctate in front, finely and closely punctate on the vertex and occiput, jaws rufous. Antennæ 14-jointed, first and second joints rufous in the female, remaining joints black, wholly black in the male. Thorax somewhat shining, very minutely and closely punctate, parapsidal grooves distinct, converging as they approach the scutellum; two short distinct lines from the collar, not extending to the middle of the thorax; a distinct median groove from the scutellum not extending to the middle of the thorax. Pleuræ finely rugoso-punctate with a smooth shining area. Scutellum very rugose, black. Abdomen red becoming piceous posteriorly in the female, wholly black in the male. Legs reddish yellow in the female, somewhat darker in the male. Wings hyaline, radial area brown in the female, veins brown, areolet indicated by a brown dot. In the male the brown radial cloud is wanting. Length of male 1.50 to 2 mm.; of female 2 to 2.50 mm.

Gall (Plate XLV, Figs. 10–12).— Polythalamous. Irregularly rounded or elongated puffy swellings situated on one side or completely encircling a branch or stalk. It occurs singly, or a number of the galls are strung along the branch in more or less close proximity, or they are more or less confluent. Internally it is soft, porous, sponge-like. The outer skin is rather brittle, especially when dry, with numerous longitudinal fissures. It measures from about 4 to 12 mm. in length and 4 to 9 mm. in width. On a species of wild rose (*Rosa* sp.).

Habitat: West Cliff, Custer Co., and Colorado Springs, Colorado (T. D. A. Cockerell); abundant in the foot hills in north and south Colorado (C. P. Gillette).

Ashmead's types are in the United States National Museum.

Rhodites nebulosus *Bass.*

Rhodites nebulosus Bassett, Trans. Am. Ent. Soc., Vol. XVII, 1890, p. 63.
Lytorhodites nebulosus Kieffer, Bull. Soc. Nat. Hist. Metz, 2 Ser., Vol. X, 1902, p. 97.

Female.— Head black, very broad, front from the eyes and including the base of the antennæ perfectly flat; ocelli prominent, and included in a smooth, shining space bounded by a distinctly impressed line, outside of this space the vertex is hairy and finely reticulated; antennæ 14-jointed; joints one and two deep brownish yellow, remaining joints black, third as long as the first and second together. Thorax black, covered with fine short hairs, evenly punctate, parallel lines distinct and reaching half way to the scutellum; parapsidal grooves distinct and reaching three-fourths of the way to the collar; lines over the base of the wings distinct and closely approaching the parapsides anteriorly; scutellum rugose and with fine short hairs; no foveæ, but a straight, prominent, transverse ridge separates the scutellum from the pronotum. Abdomen clear, semitranslucent brown, but evenly shaded. Legs pale brown, almost yellow. Wings yellowish hyaline, radial area heavily clouded, with a small clear spot in the middle; veins heavy, dark brown, almost black; areolet large distinct; radial area open, or but partly closed. Length, 2.75 mm.

Gall (Plate XLVII, Figs. 1–3).— Monothalamous. Green, globular, hollow, thin shelled, almost smooth or with very short, fine, weak spines. They occur singly on the leaves or in clusters, or in a large mass containing numerous galls. Measure from 5 to 6 mm. in diameter. On wild roses (*Rosa blanda, R. rubiginosa*, and probably *R. carolina* and *humilis*).

Habitat: Waterbury, Connecticut (Bassett); Bronx, New York City (W. B.); Guelph Canada (Jarvis).

When dry the gall becomes brittle and may be easily crushed. The type is a single imperfect specimen. I have taken *nebulosus* in abundance in the Borough of the Bronx, but did not succeed in obtaining the adults. The fly is known only by a single female in the collection of the American Entomological Society. It was erroneously described by H. F. Bassett as a male.

Rhodites politus *Ashm.*

Rhodites polita Ashmead, Bull. 1, Col. Biol. Assoc., 1890, pp. 14, 38; Gillette. Ent. News, Vol. III, 1892, p. 246. Cockerell, Ent. Student, Vol. I, 1900, p. 10,

Male and female.— "Length variable, from 2–4 mm. Entirely black with red legs. The head and thorax are finely confluently punctate, with some coarser scattered punctures over the surface. Antennæ 14-jointed in both sexes, black, the third joint being fully twice the length of the fourth. The mesopleuræ are usually smooth and polished. Scutellum convex, much longer than wide. The highly polished black abdomen in the female is slightly longer than the head and thorax together, compressed below, the ventral valve large, projecting, and acutely pointed. Wings hyaline, veins stout, black, the basal vein of the closed marginal cell a little angulated, the cubital cell closed, the areolet large, distinct" (*W. H. Ashmead*).

Three male specimens of *R. politus* are before me and they may be described as follows:

Male.— Head black, finely punctate, with microscopic hairs, mandibles rufous. Antennæ black, 14-jointed. Thorax black, shining, very finely and sparsely punctate; each puncture with a short hair. The parallel anterior lines very fine and narrow, but distinct. Parapsidal grooves very narrow, converging as they approach the scutellum, where they are widely separated. Pleuræ finely rugoso-punctate with a large polished area. Scutellum rugoso-punctate. Abdomen black, piceous basally. Legs yellowish. Wings hyaline, veins dark brown without brown radial cloud. Length 2 mm.

Gall.— Globular, sometimes coalescing. Thin walled and hollow inside. Externally it is beset with weak spinules. It occurs on the leaves of wild rose (*Rosa californica*).

Habitat: Los Angeles, California; Dakota; Colorado (Cockerell); Manitou, Colorado (Gillette).

The gall of *Rhodites politus* is the same as that of *Rhodites nebulosus*, and when we have more knowledge of these two species they may be found to be identical, and if so *R. nebulosus* will have precedence over *R. politus*. The types are in the United States National Museum.

Rhodites gracilis *Ashm.*

Rhodites gracilis Ashmead, Proc. U. S. Nat. Mus., Vol. XIX, 1897, p. 135.

Male and female.— Length 2.2 to 3 mm. In the male the two basal antennal joints and legs are red; in the female the whole abdomen is red; rest of the insect black. Head finely, closely punctate, the vertex almost smooth, thorax, scutellum and pleuræ rugose, parapsidal grooves distinct posteriorly, somewhat obliterated by the sculpture anteriorly, the middle lobe with a central longitudinal depression. Antennæ 14-jointed, the third joint very long, more than twice as long as fourth. Wings hyaline, veins brown, the areolet large, cubital cell almost closed; in the female the basal veins of the closed radial cell and radius is surrounded with a dusky cloud, which is wanting in the male.

Gall (Plate XLVII, Fig. 4).— An irregular, inflated, rounded gall, with the top broadened and somewhat flattened, the edges surrounded with short, blunt tubercles which are the apices of the elevated ribs at the sides. Inside it is hollow with the wall about 1 mm. thick. It measures about 5 mm. in diameter.

Habitat; Unknown.

The above are Dr. W. H. Ashmead's descriptions of the gall-flies and galls of *Rhodites gracilis.* They were described from four specimens, one female and three males, reared May 17, 1870, from several specimens of the galls. The name of the rose on which the gall occurs is unknown. Dr. Ashmead states that according to C. V. Riley in his note book: "A small gall, bearing a general resemblance to a mangel-wurzel seed or large beet seed, occurring on rose trees, and especially on the single rose. The galls were first noticed in September." My figures of the gall were made from a specimen kindly given to me by Dr. Ashmead, and it is very different in shape from all the other known species of *Rhodites* galls.

The types of the gall-flies and galls are in the collection of the United States National Museum.

Rhodites rosæfolii *Ckll.*

Rhodites rosæfolii Cockerell, Ent. Month. Mag., Vol. XXV, 1889, pp. 324, 363; Ent. Student, Vol. I, 1900, p. 10; Ashmead, Bull. 1, Col. Biol. Assoc., 1890, pp. 13, 38; Gillette, Ent. News, Vol. III, 1892, p. 247.

Rhodites rosæfoliæ Cockerell, Entomol., Vol. XXIII, 1890, p. 74.

Rhodites lenticularis Bassett, Tr. Am. Ent. Soc., Vol. XXVII, 1890, p. 59; Beutenmüller, Am. Mus. Journ., Vol. IV, 1904, p. 94, fig. 8; Ins. Galls Vicin. N. Y., 1904, p. 8, fig. 8.

R. rosæfolii "Female.— Length 2 mm. Black, sparsely pubescent and somewhat coarsely irregularly punctate. Mandibles red with black tips. Antennæ entirely black, 14-jointed, the two basal joints short, nearly equal; the third, the longest joint, less than twice the length of the fourth; the joints beyond the fourth very slightly subequal to the last, the last being slightly longer than the penultimate. Face closely and distinctly punctate. Parapsidal grooves rather broad, distinct, but not sharply defined and with a delicate median groove between, extending the whole length of the mesonotum. Scutellum convex elevated. Legs reddish yellow, slightly dusky basally. Abdomen red basally, beyond the second segment black, the ventral valve sharp plow-shaped. Wings fusco-hyaline, the venation dark brown, the areolet distinct, triangular. Described from one specimen received from Mr. Cockerell and named in MS. *rosæfolii" (W. H. Ashmead).*

R. lenticularis: *Male and female.*— Head black, front finely punctate, posterior portion minutely punctate. Antennæ 14-jointed, black, first and second joints rufopiceous, wholly black in the male. Thorax black with microscopic hairs. The parallel anterior lines from the collar very indistinct and scarcely evident. Parapsidal grooves distinct, but not prominent, converging as they approach the scutellum. Median groove at scutellum short. Scutellum rugose with minute hairs. Abdomen reddish brown shining in the female and wholly black in the male. Legs yellowish brown. Wings hyaline with a more or less distinct radial cloud in the female, and wanting in the male. Length of male 1.25 mm.; of female 2 mm.

Gall (Plate XLVI, Fig. 5).— Monothalamous. Lentile-shaped in the parenchyma of the leaves, showing on both the upper and under side. Occur single or in numbers upon the same leaf. Sometimes they are confluent and of irregular outline. It

measures from 2.50 to 3 mm. in horizontal and 1 to 2 mm. in vertical diameter. It occurs on the leaves of wild roses (*Rosa lucida, R. blanda* and *R. arkansana*).

Habitat: Eastern Massachusetts (Miss Cora H. Clark); Bronx, New York City (W. B.); Custer Co., Colorado (Cockerell); Manitou and Fort Collins, Colorado (Gillette).

I am unable to separate the galls of *Rhodites lenticularis* (Plate XLVII, Fig. 5) from *Rhodites rosæfolii* (Plate XLVI, Fig. 13). A male gall-fly of *R. rosæfolii* which was given to me by Dr. Ashmead also agrees with the type of *R. lenticularis*. Prof. T. D. A. Cockerell has taken *R. rosæfolii* on *Rosa macounii*.

Rhodites fulgens *Gill.*

Rhodites fulgens Gillette, Can. Ent., Vol. XXVI, 1894, p. 159; Cockerell, Ent. Student, Vol. I, 1900, p. 10.

Lytorhodites fulgens Kieffer, Bull. Soc. Nat. Hist. Metz, 2nd Ser., Vol. X, 1902, p. 97.

Male.— Head black, rarely with a small rufous spot on the clypeus, and with microscopic hairs; coarsely and regularly rugoso-punctate, subopaque. Antennæ 14-jointed, black, first and second joints inclined to be piceous in some specimens, first joint oblong, short, second joint globose, smaller than the first, third joint long and about twice as long as the two preceding, the remaining joints shorter than the third and subequal. Thorax black, very shining, smooth with scattered pit-like punctures each bearing a short hair, pleuræ rugoso-punctate, with a small, shining, and finely punctate area. The two parallel anterior lines from the collar very short or hardly perceptible, median groove from the scutellum deep, well defined and extending forward to almost the collar. Parapsidal grooves broad and deep with large pit-like punctures, slightly or gradually converging as they approach the scutellum where they are rather widely separated from the median groove. Scutellum coarsely rugose making it subopaque. Abdomen black, shining. Legs rufous, with very short hairs, tips of tarsi black. Wings hyaline, very slightly infuscated, veins dark brown and without brown radial cloud. Length 2 to 2.75 mm.

Female.— Head variable in color. Rufous, with the front at the eyes and occiput piceous, or with the vertex only black; entirely piceous, the clypeus and cheeks rufous or with more or less rufous in front; rugoso-punctate, with microscopic hairs. Antennæ 14-jointed, first, second and sometimes part of the third rufous. Thorax with the punctures and grooves as in the male, wholly rufous with the pleuræ black with a rufous area; piceous with a rufous patch at the middle anteriorly or entirely rufo-piceous. Scutellum black with a large rufous mark. Abdomen rufo-piceous, sheath black or blackish with the basal part rufous. Legs rufous. Wings yellowish hyaline and with a faint darker radial cloud. Length 2.50 to 3.75 mm.

Gall (Plate XLVI, Figs. 2–4).— Monothalamous when single, polythalamous when confluent. Spherical, hard, woody, nodules on the roots beneath the ground or on the stalk very close to the ground. Sometimes they are single or in clusters, or two or more are coalescent, forming an irregularly rounded mass. Sometimes they grow on one side of the root or stalk or completely around them. The individual nodules measure about 4 to 6 mm. in diameter and the coalescent ones from about 10 to 30 mm. in diameter. On sweet briar (*Rosa rubiginosa*).

Habitat: Bronx, New York City; Pullman, Washington; South Dakota.

This species was heretofore known from the gall-flies only. It was described by Gillette from seventeen flies sent to him by Professor J. M. Aldrich, from South Dakota, and eleven specimens bred in his laboratory. The galls were in both cases lost or confused with others. The above descriptions of the gall-flies and galls were made from specimens collected by me in the Borough of the Bronx, New York City. Some of the flies which were bred are identical with one of the female types of *Rhodites fulgens* sent to me by Professor Gillette. I have also received the gall and two female flies from Mr. A. L. Melander, from Pullman, Washington, and galls from E. B. Southwick, collected on Staten Island, New York City.

The types are with Prof. C. P. Gillette, and one female is in the collection of the American Museum of Natural History.

Rhodites radicum *O. S.*

Cynips semipiceus Harris, Rep. Ins. Mass. Inj. Veget., 1841, p. 400; Treat. Ins. New Engl. Inj. Veget., 2d ed., 1852, p. 436; Treat. Ins. Inj. Veget., 3d ed., 1862, p. 549; *ibid.*, Flint ed., 1862, p. 549; *ibid.*, 1863, p. 549; Osten Sacken, Ent. Zeit. Stettin, Vol. XXIII, 1861, p. 415.

Rhodites radicum Osten Sacken, Proc. Ent. Soc. Phil., Vol. II, 1863, pp. 42, 45, 46; Mayr, 20 Jahrb. Communal Oberrealsch., I, Bez. Wien, 1881, p. 18; Ashmead, Trans. Am. Ent. Soc., Vol. XII, 1885, p. 293; *ibid.*, Vol. XIV, 1887, p. 134; Bull. 1, Col. Biol. Assoc., 1890, p. 38; Beutenmüller, Bull. Am. Mus. Nat. Hist., Vol. IV, 1892, p. 246, pl. ix, fig. 3; Am. Mus. Journ., Vol. IV, 1904, p. 92, fig. 2; Ins. Galls Vicin. N. Y., 1904, p. 6, fig. 2; Gillette, Ent. News, Vol. III, 1892, p. 247; Webster, Bull. 45, Ohio Agricul. Exp. Sta., 1893, p. 156; Cockerell, Ent. Student, Vol. I, 1900, p. 10; Cook, Proc. Ind. Acad. Sci., 1904, p. 225; 29th Rep. Dept. Geol. & Nat. Hist. Res. Indiana, 1904 (1905), p. 817, fig. 11.

Tribalia batatorum Walsh, Proc. Ent. Soc. Phil., Vol. II, 1864, p. 470; Ashmead, Trans. Am. Ent. Soc., Vol., XII, 1885, p. 294; *ibid.*, Vol. XIV, 1887, p. 134; Proc. Ent. Soc. Wash., Vol. V, 1903, p. 222; Psyche, Vol. X, 1903, p. 210; Kieffer, Bull. Soc. Nat. Hist. Metz, 2d Ser., Vol. X, 1902, p. 96.

Male and female.— Head black, with microscopic hairs, front rugose, finely and densely punctate posteriorly. Antennæ black, 14-jointed, first and second joints rufous in the female, wholly black in the male. Thorax black, densely, but very finely and uniformly rugose, subopaque. From the collar are two lines which scarcely extend to the middle of the thorax. A fine, narrow, distinct, median groove from the scutellum to the two parallel anterior lines. Parapsidal grooves broad, distinct with large pit-like punctures and gradually converging as they reach the scutellum; at this point they are almost contiguous and separated only by the median groove. Pleuræ rugose with a large shining area. Scutellum very rugose. Abdomen black or piceous in both sexes, shining, smooth. Legs rufous with the hind femora infuscated. Wings subhyaline, yellowish, radial area clouded in both sexes. Length of male 2.50 to 3 mm.; of female 3 to 4 mm.

Gall (Plate XLVII, Figs. 7, 8).— Polythalamous. Very variable in shape and

size. Irregularly rounded, tomato-shaped or shaped somewhat like an artichoke tuber. It is smooth, reddish brown and more or less irregularly grooved and depressed. At the place of attachment is a very deep impression. Internally it is pithy and contains many larval cells. It occurs at or on the roots of wild rose (*Rosa carolina*) and is attached on a short stalk. Measures about 35 to 60 mm. in diameter.

Habitat: Canada; Massachusetts; Connecticut; New York; New Jersey; Pennsylvania; Washington, D. C.; Ohio; Indiana; North Carolina; Illinois.

This species is quite common locally in swampy places in the vicinity of New York City. It undoubtedly will be found everywhere in the range of distribution of its host plant (*Rosa carolina*). This plant is found, according to Britton and Brown, from Ontario, Canada, to Minnesota, south to Florida and Mississippi. The records of *Rhodites radicum* from Colorado by Ashmead, Cockerell and Gillette probably belong to *Rhodites utahensis*.

Walsh's description of the gall-fly of *Tribalia batatorum* agrees fairly well with *Rhodites radicum*, and it is undoubtedly the same. The description of *T. batatorum* was made from an undeveloped female obtained from an irregular mass of several dozen egg-shaped cells with a very smooth internal surface, connected by fleshy, potato-like matter, and about .17 or .18 inches long. The whole, as Walsh learned from a reliable source, was attached, apparently by a wooden peduncle, to a common potato, many other such galls having been found on other potatoes. Dr. William H. Ashmead informed me some time ago that he had investigated this matter and was in possession of conclusive evidence that Walsh's galls were the same as those of *Rhodites radicum* and that Walsh received his specimen from a farmer, who found them while plowing his potato-patch and sent them to the "State Entomologist" as being "potato-galls" owing to their resemblance to a potato. The types of *R. radicum* are in the Museum of Comparative Zoölogy, Cambridge, Mass. The types of *T. batatorum* have been destroyed.

Rhodites utahensis *Bass.*

Rhodites utahensis Bassett, Trans. Am. Ent. Soc., Vol. XXVI, 1890, p. 62; Cockerell, Ent. Student, Vol. I, 1900, p. 10.

Male and female.— Head black, front roughly punctate, posterior portion very finely punctate with a number of widely separated pit-like depressions and microscopic hairs, jaws rufous. Antennæ 14-jointed, black, first and second joints in the female rufous, wholly black in the male. Thorax very glossy, microscopically punctate with scattered pit-like depressions each bearing a short hair. Pleuræ rugose. From the collar to the middle of the thorax are two parallel lines and a fine narrow median groove from the scutellum almost reaching forward to the middle of the thorax. Parapsidal grooves deep and strongly punctate, and suddenly converging as they approach the scutellum, where they are widely separated. Scutel-

lum very rugose, subopaque. Abdomen shining black or piceous. Legs rufous with short hairs. Wings subhyaline, yellowish, veins brown without radial cloud. Length of male 2.33 mm.; of female 3 to 4 mm.

Gall (Plate XLVII, Fig. 6).— Polythalamous. Bright red, smooth. Irregular in shape, warty, with the sides and top very deeply incised as though it had been grooved out with a knife in a rosette-like fashion. It is soft when fresh and pithy internally with numerous larval cells. On the under side is a deep impression where it is attached by a short stalk to the lower part of the plant or roots. It occurs on different species of wild roses (*Rosa pisocarpa* and probably *R. woodsii*).

Habitat: Southern Utah; Topaz Butte near Florissant, Colorado (W. M. Wheeler); Pullman, Washington.

Allied to *Rhodites radicum*, but the gall-flies may be readily distinguished by having the thorax on top very glossy, minutely punctate with scattered pit-like depressions, each bearing a short hair. The parapsidal grooves suddenly converge at the scutellum and are more widely separated at this point than in *R. radicum*. The gall is somewhat similar to that of *R. radicum* but may be distinguished readily by the deeply rosette-like incisions on the upper parts. The types of *R. utahensis* cannot be found in the Bassett collection.

EXPLANATION OF PLATES.

Plate XLIII.

Figs. 1–4. *Rhodites bicolor* (Harris).
Figs. 5–6. *Rhodites rosæ* (Linn.).
Figs. 7–10. *Rhodites ignotus* Osten Sacken.

Plate XLIV.

Fig. 1. *Rhodites vernus* Osten Sacken (type).
Figs. 2–6. *Rhodites globuloides* sp. nov.
Figs. 7–8. *Rhodites neglectus* Gillette (type).
Figs. 9–12. *Rhodites dichlocerus* (Harris) (smooth form).
Figs. 13–14.— *Rhodites dichlocerus* (Harris) (spiny form).

Plate XLV.

Fig. 1. *Rhodites arefactus* Gillette (type).
Figs. 2–4. *Rhodites similis* Ash. (= *R. arefactus*) (cotypes).
Figs. 5–7. *Rhodites tumidus* Bassett (types).
Fig. 8. *Rhodites tuberculator* Cockerell.
Fig. 9. *Rhodites tuberculator* Cockerell.
Fig. 10. *Rhodites tuberculator* Cockerell.
Figs. 11–12. *Rhodites multispinosus* Gillette.
Fig. 13. *Rhodites arefactus* Gillette.

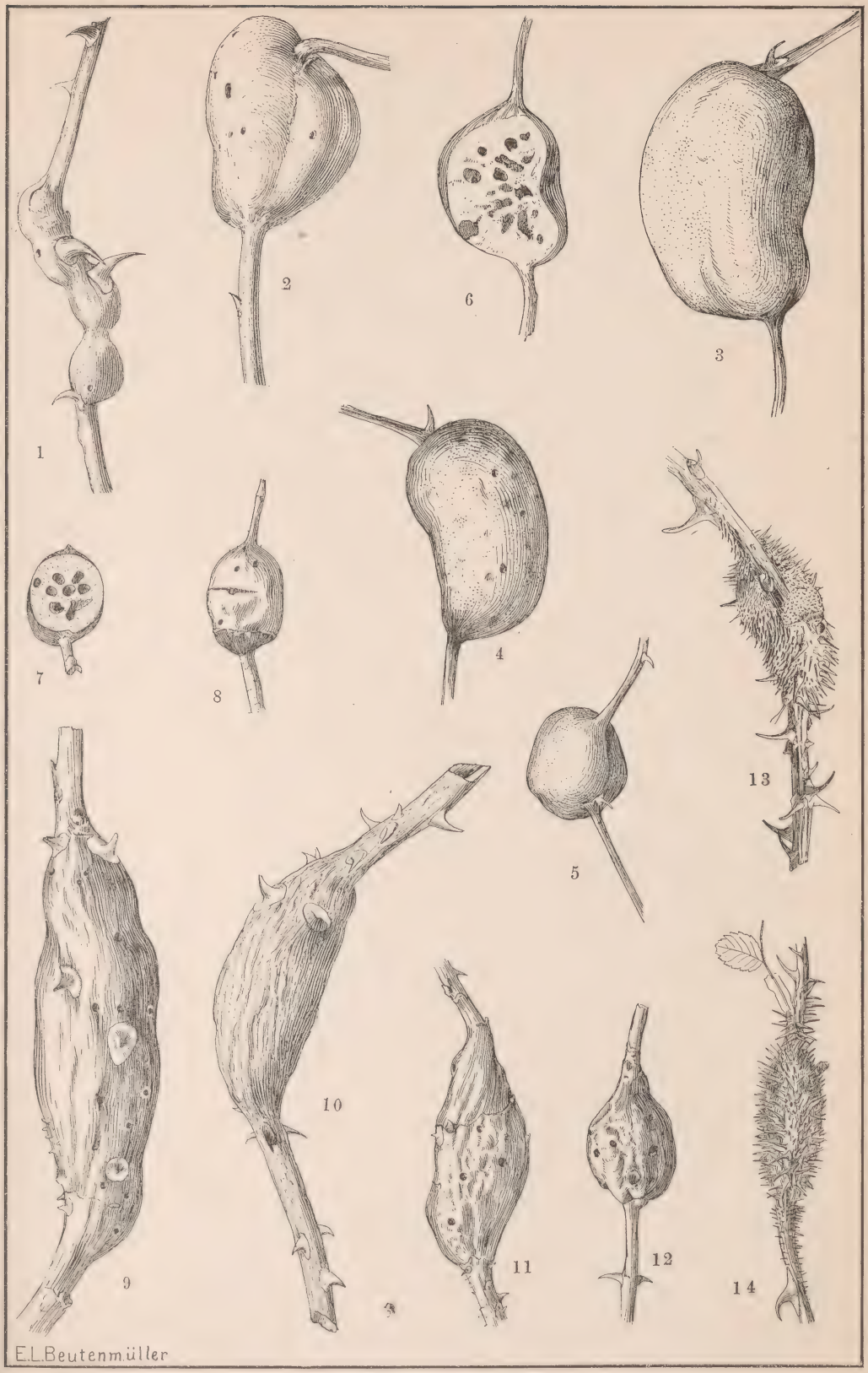
PLATE XLVI.

Fig. 1. *Rhodites multispinosus* Gillette (type).
Figs. 2–4. *Rhodites fulgens* Gillette.
Figs. 5–9. *Rhodites variabilis* Bassett.
Figs. 10–12. *Rhodites fusiformans* Ashmead.
Fig. 13. *Rhodites rosæfolii* Cockerell.

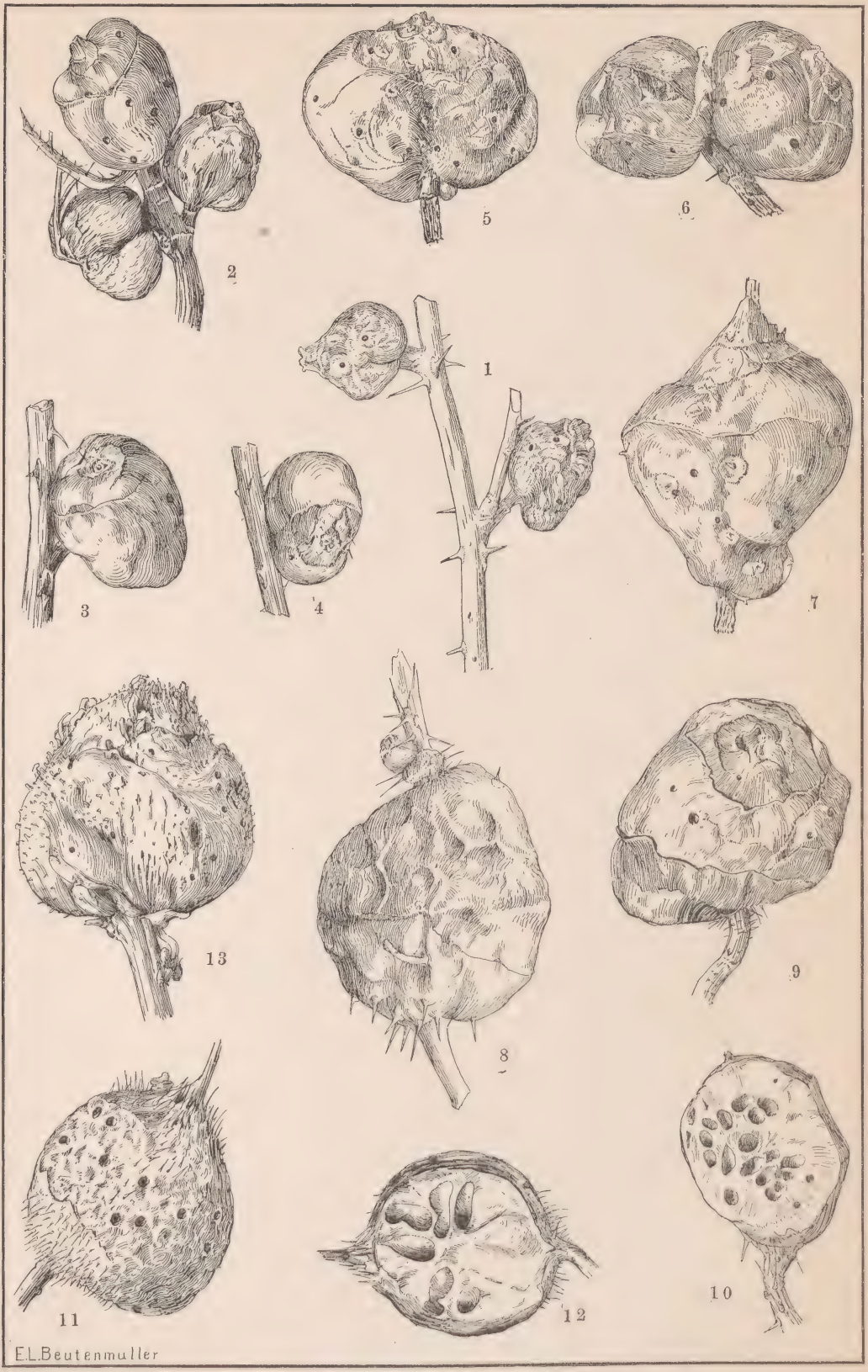
PLATE XLVII.

Figs. 1–3. *Rhodites nebulosus* Bassett.
Fig. 4. *Rhodites gracilis* Ashmead.
Fig. 5. *Rhodites lenticularis* Bassett.
Fig. 6. *Rhodites utahensis* Bassett.
Figs. 7–8. *Rhodites radicum* Osten Sacken.

North American Rose-Galls.



North American Rose-Galls.



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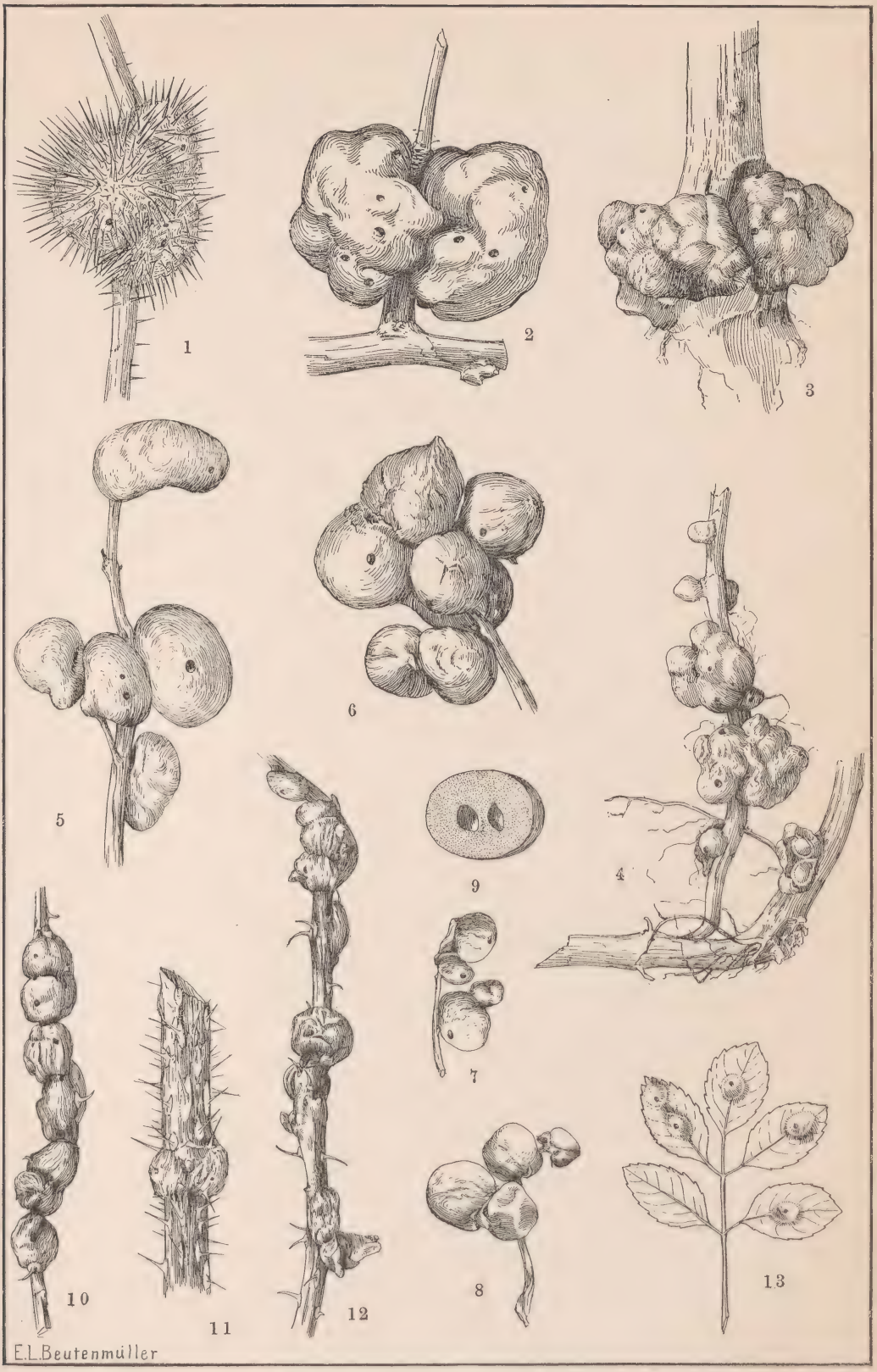

North American Rose-Galls.

North American Rose-Galls.

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Article XXVIII.—DESCRIPTION OF THE SKULL OF *BOLOSAURUS STRIATUS* COPE.

By E. C. Case.

Plate XLVIII.

During the summer of 1907 the author made a collecting trip in the Permian beds of north central Texas the proceeds of which passed into the possession of the American Museum of Natural History in New York. Among the material collected were two skulls of a small reptile, *Bolosaurus striatus* Cope, hitherto known from a very imperfect skull which formed the type. The purpose of the present paper is to describe these two skulls and to establish the position of the family Bolosauridæ, which has been in some doubt.

The two skulls were found close together with numerous bones of *Clepsydrops, Dimetrodon,* etc., in a bed of conglomerate in the Clear Fork division of the Texas Permian beds. The locality is near the mouth of Godlin Creek, in the northern portion of Archer County, Texas.

Order COTYLOSAURIA Cope.

Fam. Bolosauridæ Cope.

The family was originally regarded by Cope as belonging to the *Pelycosauria.* He said[1]: "The division *Pelycosauria* is established primarily upon the genera *Clepsydrops* and *Dimetrodon,* but their cranial structure renders it highly probable that *Ectocynodon, Pariotichus* and *Bolosaurus* belong to it. It is also probable that the genera *Empedocles, Embolophorus* and others determined from vertebræ belong to it, as the later are frequently accompanied by pelvic bones of the type of that of *Dimetrodon.* All the genera known from teeth and crania, are of carnivorous habit, excepting *Bolosaurus* and *Diadectes*; they may be referred to a single family on this account, which I call the *Clepsydropidæ. Bolosaurus* will form the type of another family characterized by the transverse position of the crowns of the teeth, under the name *Bolosauridæ.*" In his Systematic Catalogue of the Permian Reptiles published in 1888[2] Cope placed *Chilonyx* in the family

[1] Proc. Am. Phil. Soc., Vol. XVII, p. 529, 1878.
[2] Trans. Am. Phil. Soc., Vol. XVI, pp. 285–297.

Bolosauridæ, indicating that he recognized the Cotylosaurian character of the skull.

Revised description of the family: Small Cotylosaurians with the cheek teeth elongate transversely and with a prominent cusp, in the upper series on the outer edge and in the lower series on the inner edge; the cusps showing slight wear in mature specimens. The family is distinguished from the Pariotichidæ by the presence of the cusps on the teeth and by the presence of but a single row in the lower jaw, and from the Diadectidæ by the presence of an elongate parasphenoid rostrum and a prominent outer process of the pterygoid bearing a row of teeth on the lower edge.

Genus **Bolosaurus** Cope.

Bolosaurus striatus Cope.

Original description of the genus and species, 1878[1]: "Teeth fixed in shallow alveoli, and with the crowns expanded transversely to the axis of the jaws. The crowns swollen at the base, and with low apex, divided vertically into two equal portions. The postero-internal half in the maxillary series is low and horizontal; the anterior external portion forms a low cusp, which has a semicircular section. The teeth of the lower jaw are similar, but the relative positions of the ledge and cusp are reversed. Anterior teeth of superior series composed of external cusp and internal ledge. No enlarged canine or incisor teeth. Bones of face not sculptured."

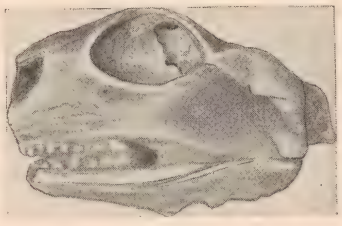

Fig. 1. Sketch showing the condition of the type specimen, No. 4320, Am. Mus. Nat. Hist., Cope Coll. The character of the teeth is shown on the opposite side (see Fig. 6). Natural size.

"*Char. Specif.* The external surface of the crown is marked to the apex with waved grooves of enamel. The edges of the elevated cusp, which presents posteriorly in the maxillary teeth, constitutes the abrupt termination of the exterior face, and is serrate by the interference of the sulci. The edge of the basal ledge is slightly serrate. The muzzle is rather elongate, and the sides of the maxillary and dentary bones are plane and smooth. The mandible is narrow, and forms a narrow wedge in the profile outline. It rises posteriorly behind the dental line. The teeth are separated by intervals as wide as the tooth.

"*Measurements.*	M.
"Long diameter of the orbit No. 1	.0130
Depth of upper jaw at orbit	.0045
Depth of lower jaw at front of orbit	.0050
Four teeth in (lower jaw)	.0080
Elevation of a crown	.0025
Transverse diameter of molar number 2	.0025"

The foregoing description was evidently taken in large part from the

[1] Proc. Am. Phil. Soc., Vol. XVII, p. 509.

type skull, No. 4320 Am. Mus. Nat. Hist., Cope Coll., but there are some parts which were taken from No. 4321, and perhaps from other specimens.

Revised description of the genus and species. The following description is taken almost entirely from the two skulls recently discovered, as the type skull shows very little that can be depended upon, other than the characteristic form of the teeth in the lower jaw. The condition of the type renders it impossible to make out the separate bones, and the teeth of the upper jaw have been nearly all broken away. The whole skull has been crushed forward giving a false appearance of elongation (see Fig. 1).

Fig. 2. Side view of the skull of No. 4686, showing the dentition, shape of the orbit, etc. Natural size.

The two skulls, Nos. 4685, 4686, are of nearly equal size and in a good state of preservation; one has been crushed downward so that the top of the skull is broken in, but the palatal surface is well shown; the other has been crushed somewhat from side to side, but with the exception of the tip end of the nose there has been little loss. Unfortunately both specimens have been so injured in the temporal region that it is impossible to make out the limits of the individual bones, but there is no doubt that there was a complete roof with no trace of temporal vacuities.

The skull was roughly triangular in form, wider and higher posteriorly and terminating in a blunt snout anteriorly. The interorbital space is moderately wide and slightly concave or flat and is pierced by a fair sized parietal foramen. The facial portion of the skull seems to have been rather sharply rounded above. The anterior end of the skulls is so injured that it is not possible to determine the exact position of the nares but they were nearly terminal and apparently looked outward rather than forward. The orbits are large and were nearly circular in outline; the antero-posterior diameter is nearly equal to the preorbital length of the skull. The edges of the orbit are prominent above and anteriorly but are less so below; there is no pit in the prefrontal such as is so characteristic of the Pelycosauria.

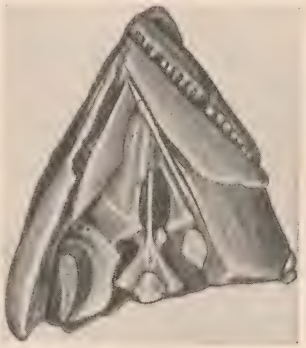

Fig. 3. View of the lower surface of No. 4686, showing the condition of the palatal region. Compare Fig. 4.

From the condition of the specimen it is impossible to make out the shape or relations of all the bones but it is evident that their surface was smooth and free from sculpture except along the anterior edge of the orbit.

The *maxillary* is rather elevated with a convex superior edge and a nearly straight alveolar edge; posteriorly it extends almost to the back of the orbit but is prevented from taking any part in it by the jugal which overlies the posterior fourth. There are 16 counted teeth in the best preserved specimen, which is evidently a nearly perfect premaxillary and maxillary series. The anterior three teeth, which probably belong to the premaxillary, are larger than the anterior maxillaries and probably functioned as incisors. In common with the anterior maxillaries they are simple cones with large pulp cavities. Beginning with the sixth tooth the maxillary series increases in size to the tenth or eleventh, and then decreases in size to the posterior end; the last two are abruptly smaller and are only minute cones. The teeth from the sixth to the fourteenth show the characters of the family and genus. They are transversely expanded, much as in the Diadectidæ, but in a less degree, and on the outer edge there is a prominent cusp which descends considerably below the rest of the crown. The apex of this cusp was originally sharp but seems to have been worn blunt by attrition. The shape of these teeth indicates the assumption of an herbivorous habit and perhaps indicates the method of development of the Diadectid teeth.

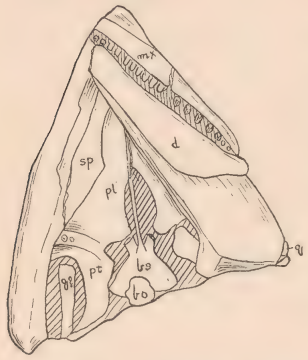

Fig. 4. Diagram of the lower surface of No. 4686, showing the form of the various bones.

The exact outlines of the frontals, nasals, prefrontals and lachrymals cannot be made out; the frontals were paired and took part in the upper edge of the orbit.

The *jugal* is a long and slender bone which underlay the orbit and extended relatively far anterior and posterior to it; it did not extend upward to form a portion of the posterior edge as in the Pelycosauria.

The postorbital region is crushed in both specimens but in them and in the type specimen it is evident that the region was covered by a complete roof without temporal vacuities. The form of the separate bones is obscure. The quadrate is a vertical plate and the articular surface has two condyles, elongate antero-posteriorly as in the Diadectidæ.

The posterior surface of the skull is composed of a nearly vertical plate in which the sutures are mostly indistinguishable; the *exoccipital* is fused with the basioccipital and extended well up on the sides of the large and nearly circular foramen magnum. The occipital condyle is slightly oval and is marked by a pit showing the termination of the notochord. The *opisthotic* is separate from the exoccipital and extends out to the quadrate as a strong process. On either side of the posterior face of the skull there is a good sized posttemporal vacuity. There is no trace of a foramen quadratum.

The under surface of the skull is most interesting, showing the strong resemblance to the Pariotichidæ in the presence of the strong parasphenoid rostrum and the external process of the pterygoids, points in which it differs from the Diadectidæ. The *basisphénoid* is shaped much like that in the Pelycosauria and the Pariotichidæ; attached to the anterior end is a slender *parasphenoid rostrum*, which is of exceptional length; it extended far forward between the palatines. The posterior end is expanded and the lower surface is excavated by a shallow pit; near the anterior end are prominent basipterygoid processes which bear smooth articular faces. There is no trace of foramina for the external carotids on the lower surface but these may be very obscure because of their minute size and the condition of the surface of the bone. In the specimen numbered 4685 the basioccipital has been pushed forward out of place and lies partly in the pit at the posterior end of the basisphenoid.

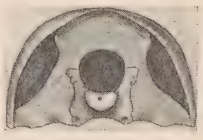

Fig. 5. Posterior view of skull No. 4686.

The *pterygoid* has the tripartite form made familiar in the Pelycosauria and the Diadectidæ. The anterior process extends forward and fuses with the palatine so intimately that the suture cannot be made out; between the pterygoids and palatines of the two sides there is considerable space which is divided by the elongate parasphenoid rostrum; it is probable that the anterior end of the dividing plate is formed by the *vomer*. The external process of the pterygoid curves outward from the middle of the bone and presents a prominent vertical face to the inner side of the lower jaw. The lower edge of this process carries a row of prominent, bluntly conical teeth set in sockets. There are six teeth in the best preserved row with the base of a seventh set off to one side; the outer end of the row of teeth is bent sharply forward with the process.

Fig. 6. Teeth of the lower jaw in the type, showing the character of the genus and family. Natural size.

The *lower jaw* is very high posteriorly and becomes more slender anteriorly. The alveolar edge is nearly straight as in the maxillary, and there are 13–14 counted teeth and alveoli; this series does not seem to be complete and there were probably one or two more. As in the upper jaw, there is no trace of enlarged canines and the teeth in the middle of the series are somewhat larger than those at the ends; the last two teeth are abruptly smaller. The teeth of the middle portion of the series have a very similar appearance to those of the maxillary; the base of the crown is swollen and the inner edge is continued upward in a cone which was sharp originally but seems to be worn blunt by use. The articular region shows two cotyli for the condyles of the quadrate, and is expanded laterally for their accom-

modation as in the Diadectidæ. Though the posterior portion of the jaw is very high there is no distinct coronoid process, and there are no vacuities in the outer surface of the jaw. The relations of the various bones cannot all be made out but it is evident that the splenial extends far forward and took part in the symphysis.

Measurements.	mm.
Length of the lower jaw of No. 4685, perfect	31
Width across the posterior end of the skull	28

With the skulls there were found numerous limb bones and vertebræ of some animal or animals of about the size indicated by the skulls, and they may belong to *Bolosaurus,* but as they were found in a bone bed, and as the remains of several small specimens of *Clepsydrops* were found in the immediate vicinity, it seems hardly profitable to describe them until further evidence has been obtained.

The affinities of this small Cotylosaurian are evidently with the Pariotichidæ rather than with Chelydosauria, but it differs from the Pariotichidæ in the presence of but a single row of teeth on the lower jaw and in the presence of cusps on the teeth. The swollen base of the teeth strongly resemble those of *Pantylus cœcodus* Cope, but that form is much larger and the teeth are without cusps. *Bolosaurus* is evidently a representative of a family of the Cotylosauria which was just assuming the habit of an herbivorous diet.

Explanation of Plate XLVIII.

Upper jaw of *Bolosaurus,* No. 4321, Am. Mus., Cope Coll. *A,* external view; *b,* internal view; *c,* inferior view. Enlarged four diameters. Photo. by A. E. Anderson.

Bolosaurus striatus.

55.1,75(76.4)

Article XXIX.— THE CHARACTER OF THE WICHITA AND CLEAR FORK DIVISIONS OF THE PERMIAN RED BEDS OF TEXAS.

By E. C. Case.

The Red Beds commonly reckoned as Permian in Texas are separable into three main divisions, the Wichita, Clear Fork, and the Double Mountain. The lower two of these, only, carry any vertebrate remains and pretty closely within the limits of Wichita, Baylor, Archer and Willbarger Counties, though there have been bones found north in the vicinity of the Wichita Mountains and along the north line of Oklahoma.

During the summers of 1896, 1903, and 1906 the author worked in these beds collecting vertebrate fossils and gave considerable attention to an attempt to unravel the stratigraphy of the region in order to more definitely locate the horizons of the animals discovered. This matter proved to be of very great complexity because of the discontinuity of the layers and their rapid change in character; but the observations of three years make it possible to offer a tentative arrangement of the strata. It is very evident that this region, like the Lower Permian of Africa and India, the Ecca and Talchir formations, is largely river-deposited material in some old delta or on some shallow tidal coast. The source of the material was pretty certainly the elevation to the north now represented by the Wichita Mountains.

Fig. 1. Sketch map of the portion of Texas where the Permian beds occur, showing the location of the sections given in Fig. 2.

The bulk of the beds in all three divisions is a fine red clay, but this is interspersed with beds of sandstone, conglomerate and impure limestone. The lowermost, the Wichita division, is

largely clay, but the Clear Fork has a much more varied character. The Clear Fork plainly represents a period when the seas were more shallow than in the preceding and the deposits were made on wide flats, in relatively confined channels with swift currents or in wide lagoons. There is a total absence of invertebrate fossils from the sandstone and clay in this division, the few shells that have been found coming from the thin layers of impure limestone; a few ferns have been collected from the layers of fine sandstone. As in the other divisions the Clear Fork is largely made up of thick beds of bright red clay, which is commonly filled with nodules and concretions but at times is very pure and free from any foreign matter. Running through the beds of red clay, however, are thin layers of sandstone which appear and disappear, thin out and change to a conglomerate or a clay in a most confusing manner; these layers are of small extent and thickness; they exhibit crossbedding to a remarkable degree and are frequently much bent; it is evident that they are the work of local currents intruding without any regularity into the deposits of clay. The red clay itself changes in color and composition in a most surprisingly sudden manner, all shades of blue, gray, buff and yellow following each other, and the changes take place almost as rapidly horizontally as vertically. The thickness of the layers of clay is also subject to most sudden and surprising changes, ranging from a few feet to twenty or thirty. It is only by the closest observation that it is possible to determine whether one of these beds of sandstone is but a small bit deposited by a local current or a portion of one of the more persistent layers which may be traced over the region.

The lower divisions in Wichita and Archer Counties are more nearly horizontal, but in Willbarger County they dip decidedly to the south and west. The presence of locally harder layers which have weathered out into shelves and flat-topped hills make this very apparent.

Among the numerous beds of sandstone which are dispersed among the clays there are a few which seem to be fairly persistent through the region. The upper one of these, separating thick layers of red clay which lie above and below it, is a sandstone varying from a few inches in thickness to many feet, and ranging in color from a bright blue through all the shades of brown, yellow and buff to a brilliant red. In some places it is very massive and even weathers out into rounded concretionary masses from five to twenty feet in diameter, but this may change in a few rods to a thin and shaly condition with pronounced crossbedding. From its prominent development near the little station of Fulda on the Wichita Valley railroad this layer of sandstone may be called the Fulda sandstone. Near this place it is quite massive and nearly twenty feet thick in places; it lies directly upon the clay beneath and disappears from the surface beneath the over-

lying layers a few miles east of the town of Seymour in Baylor County. In the valley of Godlin Creek and the portions of the valley of the Little Wichita near the mouth of Godlin Creek this sandstone terminates below in a layer of conglomerate which separates it from the clay beneath. This conglomerate is composed of small pebbles not larger than a bean and presents a uniform appearance wherever it occurs. The sandstone above is almost entirely devoid of fossils, hardly a fragment having been found in it, but the conglomerate is frequently so filled with bones that it forms veritable bone beds, and in many places isolated bones and water worn fragments may be literally shoveled up from the surface.

Below the Fulda sandstone is a considerable thickness of clay, commonly red above and gray below, but frequently showing the most brilliant and variegated shadings. Running through the clay at irregular intervals are thin layers of shaly sandstone; these are always strongly crossbedded and are frequently sharply bent. They are separated in many cases by decided unconformities from the clay above and below, but this seems rather due to the action of a pretty swift current which eroded a channel in the clay in which the sandstone was later deposited than to represent any considerable time interval between the two deposits. Frequently the clay is interrupted by beds of pebbly conglomerate formed of small iron and clay-iron concretions about the size of a bean or smaller. The position of this layer is very indefinite and it varies widely in thickness; in some places it is far below the base of the Fulda sandstone and in others it rises much nearer to it. Near the mouth of Godlin Creek this layer becomes several feet in thickness and rises until it comes in contact with the conglomerate at the base of the Fulda sandstone. These ill defined layers of uncertain extent lying in the clay evidently represent the position of transitory currents in an ordinarily quiet lagoon or over the tidal flats of a wide delta. As additional evidence of the later fact it may be stated that it is almost exclusively upon or in these thin layers of sandstone and conglomerate that the vertebrate remains are found below the level of the Fulda sandstone and conglomerate; fossils of an exceptional degree of preservation are sometimes found in the clay but their occurrence is so rare that not more than one or two specimens will be found in a summer's search. The remains which are found on or in the sand layers were evidently washed there by currents from a distant shore and they are generally more or less imperfect, having been dispersed by the action of the current or by predatory animals, while those found in the clay were evidently animals which mired down on wide mud flats or were drifted out on the surface of the stagnant lagoons.

Above the Fulda sandstone there is a considerable thickness of clay which is in many places bright red but on the south side of Godlin Creek is

bright blue with many inclusions of sulphur yellow clay stone; this shades into a red above and is capped by a layer of limestone which covers the hills over a good many square miles. This limestone, from its uniform thickness, is called in my notes, the "six inch" limestone. Just south of Fulda the stone is dark brown in color and filled with colonies of worm casts; it is very hard and has determined the level of a broad shelf which borders the valley of the stream and lies in blocks on the top and slopes of this shelf like an artificial pavement. Further to the west and north this stone becomes more shaly and changes through buff to pure white. It finally disappears beneath a red and gray clay dipping a few degrees to the west and south. Locally this stone changes into a conglomerate bearing invertebrate and even a few vertebrate remains; in one place, just south of Fulda there is a bed of limestone very similar to this but at a lower level and of small extent; it is only a couple of inches thick and contains an enormous number of small amphibian bones.

Further north, on the south side of the Big Wichita, this limestone is pure white and is represented by several layers separated by a few inches of gray clay. At one point examined, a few miles back from the river and a couple of miles east of the Seymour-Vernon road, there is a thin layer of limestone not over a couple of inches thick, which broke up into nearly perfect cubes so that, as it lies washed clean on the surface, it presents the appearance of a perfect mosaic; below this are a few inches of gray limey clay and then the main bed of limestone, which here, as further east, is uniformly about six inches thick and lies like a pavement on the slopes of the hills. A third layer of limestone presents at this point a most beautiful series of mud cracks. This limestone forms the floor of the ford where the Seymour-Vernon road crosses the Big Wichita River.

Going west from this locality the limestone disappears beneath a bed of gray and red clay filled with concretions which reaches a thickness of 20 to 30 feet. At the upper limits of the clay lies one of the most persistent layers of the region; this is a bed of hard, pebbly conglomerate from six inches to a foot in thickness and varying in color from a dark to light but having through most of its extent a deep purplish red color, which is very characteristic. This is one of the most readily determined levels of the region and may be called the Wichita conglomerate. Above the conglomerate lies a great bed of massive sandstone reaching in some places a thickness of a hundred feet; the color is in general red but it changes locally to brilliant shades of orange, yellow and blue. This bed of massive sandstone produces a very marked change in the topography; to the east of the Seymour-Vernon road the hills are low with broad shelves on the sides but to the west, where the sandstone appears, the hills are high and steep-sided, standing out in isolated mesas.

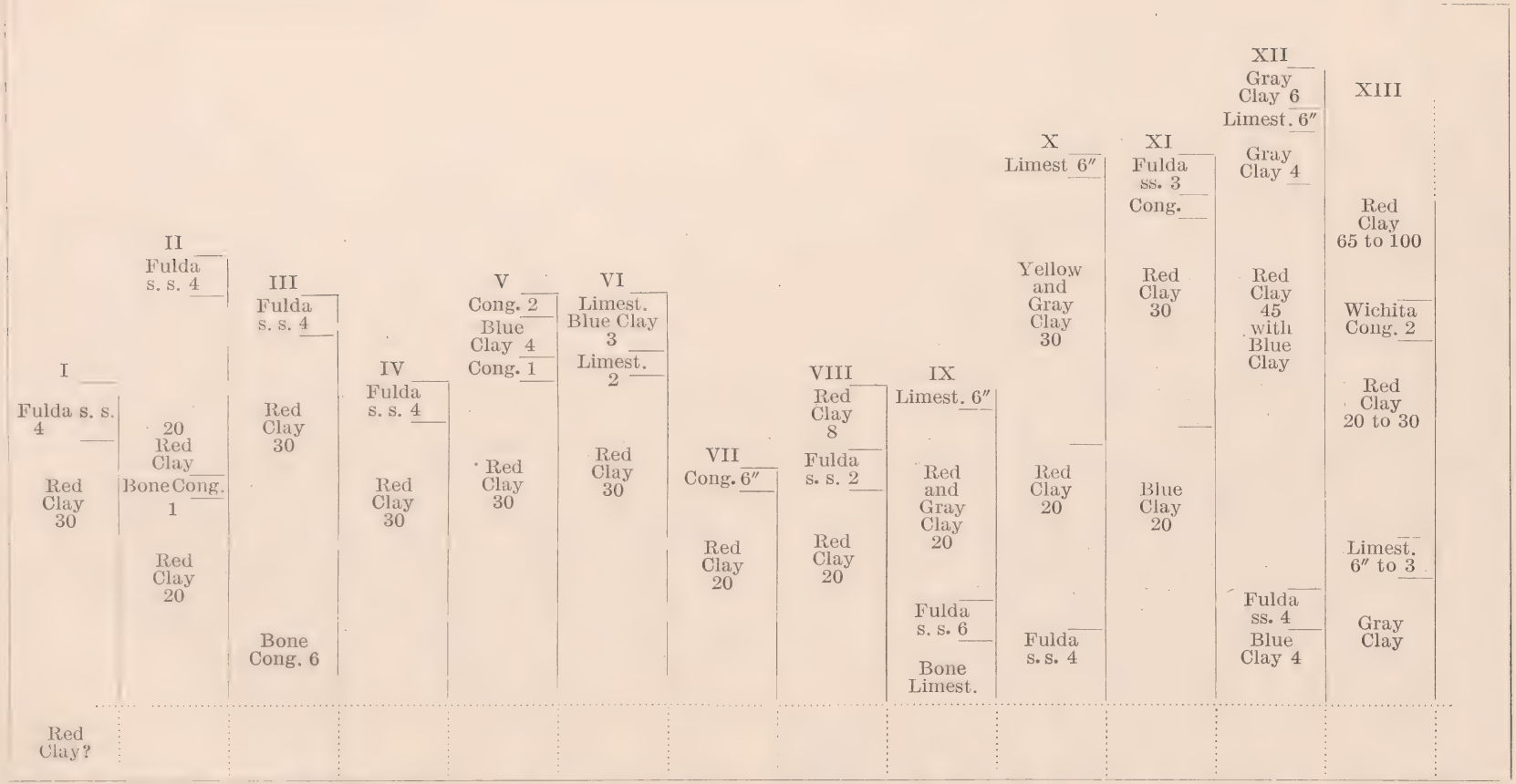

Fig 2 Sections showing the different layers at localities marked on the map (Fig. 1, p. 657). Numbers refer to thickness in feet.

To the north of the Big Wichita River the sandstone becomes thinner in places and is sharply crossbedded; it even gives place to clays locally. The tops of the high hills are marked by a thin layer of white shaly limestone which is perhaps the lowest member of the next higher group, the Double Mountain.

No invertebrates have been discovered in the upper beds, and the position of the vertebrate remains is much less easily determined but, as further east, they seem to occur on or in layers of shaly sandstone or conglomerate lying at irregular places in the clay. The Wichita conglomerate seems to be completely barren, as is the massive sandstone above, except where the sandstone exhibits local phases of a conglomeritic character. Some few bones have been found in the gray clay just above the six-inch limestone.

The whole formation seems to be very clearly the result of river deposition, either in the form of a wide delta or in very shallow water. With little doubt the material was derived from the degradation of the Ouchita Mountain mass, which was uplifted at the end of the Carboniferous and, perhaps more specifically, from the Wichita Mountains which lie directly north of the region.

(56.81.7Z(115:76.4)

Article XXX.— ADDITIONAL DESCRIPTION OF THE GENUS *ZATRACHYS* COPE.

By E. C. Case.

During the past summer, 1906, the author collected in the upper portion of the Clear Fork division of the Permian, in Willbarger County, Texas, the anterior portion of the skeleton of a small amphibian, referable to the genus *Zatrachys* Cope, and doubtfully to the species *apicalis*. This specimen, No. 4736, consists of the shoulder-girdle, ten anterior dorsal vertebræ with ribs and overlying dermal plates, other ribs, and the forelegs and foot of a small adult amphibian not exceeding two feet in length. The exact horizon is unknown as the specimen was found in the bottom of a small wash, but it evidently came from the upper part of the Clear Fork beds, above the Wichita Conglomerate.

The genus *Zatrachys* was described by Cope in 1878 [1] from the characters of the skull alone. Of the four species of this genus distinguished by Cope, *serratus, apicalis, conchigerus* and *microphthalmus, apicalis* is the only one in which the vertebræ or other portions than the skull were known or considered. This species was described in 1881,[2] as follows: "The summits of the neural spines are expanded and the superior faces of the expansion are tubercular and have a median prominence. The expansions are sometimes large, resembling the dermal bones of the crocodiles, and in that case the median prominence is a keel. On the smaller expansions the latter is a mere apex. There are narrow flat bones which I suppose to be neural spines which are ornamented with inosculating ridges. A capitular head of the diapophysis is compressed. The intercentra are well ossified, those preserved with a lateral notch. Inferior surface with crowded small fossæ, giving a delicate reticulate relief."

Fig. 1. Apex of neural spine of *Zatrachys apicalis*. Half natural size.

Fig. 2. Neural spine of *Zatrachys crucifer*. Half natural size.

In 1905 [3] the author described a fragment of a dorsal spine from Texas under the name *Z. crucifer*. This consisted of a nearly perfect neural spine 54 mm. in height with the sides of the apex extended in cross arms (see Fig. 2). The upper surface of the spine is very coarsely rugose, with deep pits.

From the above it is evident that the genus *Zatrachys* is a very uncertain

[1] Proc. Am. Phil. Soc., Vol. XVII, p. 523.
[2] Am. Nat., Vol. XV, p. 1020.
[3] Journ. Geol., Vol. XI, p. 399.

assemblage but it seems better to hold the specimens together under this name than to disperse them under different generic names on uncertain grounds.

Zatrachys was one of the armored amphibians which developed during the Permian in the North American continent. Two others now known developed the same character. Of these *Dissorophus* was very perfectly protected, the whole back being covered by a series of dermal plates corresponding in number to the ribs and covering the animal as the plates of an armadillo cover that mammal. The other, *Trimerorhachis,* was supplied with numerous strong dermal plates but as yet the plates have not been discovered in position, so that neither their arrangment nor extent is known.

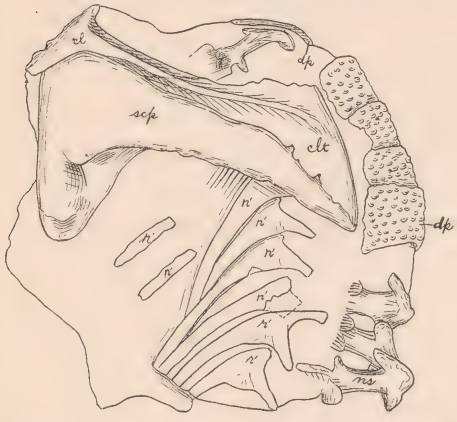

Fig. 3. Outline drawing showing the bones of left side of *Zatrachys apicalis* (?) in No. 4736. *Cl.*, clavicle; *clt.*, cleitrhum; *scp.*, scapula; *dp.*, dermal plate; *ns.*, neura spine; *r'.*, ribs of the anterior dorsal region. Half natural size.

Description of the specimen.— The *shoulder-girdle* is complete but the bones of the right side are in part covered by the bones of the right leg and foot which have been thrown up and back in process of fossilizing.

The *scapula* resembles that of *Eryops*; the shaft is elongate and slightly broadened at the distal end. There is a deep and well formed cotylus but there is no trace of separate coracoid, procoracoid or epicoracoid.

The *interclavicle* is roundly shield-shaped, without any posterior prolongation. On the center of the lower face there is a prominence with articular edges for the inner edges of the clavicles.

The *clavicles* have the anterior end flat and roughly diamond-shaped with thin edges. The lower part of the inner edge articulates with the prominence on the lower face of the interclavicle and the upper part of the edges met above the articulation with the interclavicle. The shaft is bent at an angle of about 45° to the anterior end. The section of the clavicle is like a capital L turned on its side. The long part of the L lies horizontally and the short part is turned downward and covers the outer edge of the cleithrum. The distal end reaches nearly to the posterior end of the scapula.

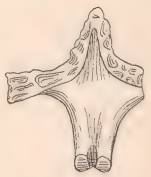

Fig. 4. Interclavicle, lower side. Half natural size.

The *cleithrum.* The posterior end is thin, wide, and closely applied to the surface of the scapula; it quickly contracts to a narrow shaft, at the same time gaining thickness until it stands as a narrow and high ridge on the surface of the scapula near the upper edge. The anterior end extends as far forward as the cotylus of the scapula.

The *humerus* has the form common to the amphibia of the Permian; the distal and proximal ends stand at an angle of about 45° to each other, and a strong deltoid process and ridge reach nearly to the middle of the shaft. There are well developed ect- and entepicondylar processes but no entepicondylar foramen.

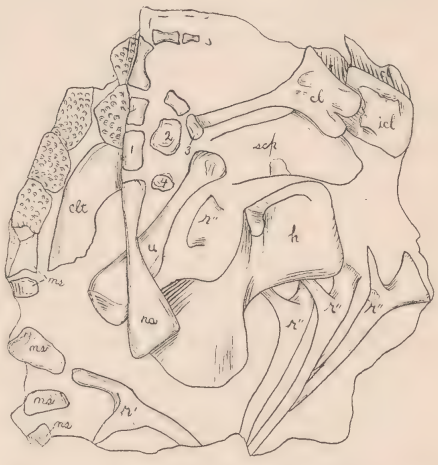

Fig. 5. Outline drawing showing the bones of the right side of *Zatrachys apicalis* (?). *Cl.*, clavicle; *icl.*, interclavicle; *clt.*, cleithrum; *scp.*, scapula; *h.*, humerus; *ra.*, radius; *u.*, ulna; *ns.*, neural spine; *r'.*, rib of the anterior dorsal region; *r''.*, ribs of the posterior dorsal region. Half natural size.

The *radius* and *ulna* are well developed but the articular ends do not show particular characters. The proximal and distal ends of both bones are rather widely expanded.

The *foot.* There are six of the carpal elements preserved, seemingly in position. Between the distal ends of the bones is a small intermedium; at the distal end of each is a larger element in the position of the radiale and ulnare. The foot is somewhat turned so that the bone which lies at the end of the ulna may be either the ulnare or the centrale 2. Below the intermedium is a good sized bone, the centrale 1. The radial digit is relatively long, and there is a stout metacarpal and three phalanges. It is not certain that the last phalanx is the terminal one as the end of the digit is obscured by matrix. The other digits cannot be exposed without injuring the specimen.

Fig. 6. Anterior view of the neural spine of an anterior dorsal vertebra with section of overlying dorsal plate in position. Half natural size.

The *vertebral column.* There are 10 anterior dorsal vertebræ preserved. The anterior six have the dermal plates preserved in position, the posterior four have lost them. The centra of the vertebræ cannot be made out but the neural arches are all free and there is little doubt that the general form is similar to that of *Trimerorhachis.* There are well developed anterior and posterior zygapophyses and from the base of the posterior one a narrow, winglike process extends downward and outward for the head of the rib. This process was attached solely to the neural arch. The neural spines are stout and strong with the apex expanded and rugose. The expansion of the apex of the spine in the posterior vertebræ is more nearly circular, but even here the lateral edges are more extended than in the fore and aft edges. In the anterior vertebræ the sides become widely expanded, the projections extending outward and downward and meeting above in an angle, like an inverted V.

Each of the anterior six vertebræ has the neural spine overlain by a single dermal plate in the form of an inverted V closely conforming to the apex of the spine and closely applied to it. The two sides of the plate meet in an angle of 120° to 130° but there is no median ridge nor any trace of a suture to indicate that the plates were originally separate. The plates overlap each other from before backward and did not extend laterally far beyond the extension of the neural spine; the upper surface is rugose with deep pittings. There is no trace of any lateral plates overlying the ribs, and the condition of the specimen is such that if plates had existed they would very likely have been preserved. The distal ends of the scapula and the cleithrum lie under the edges of the dermal plates, and it is likely that in life they nearly touched the edges of the neural spines.

The *ribs* attached to the vertebræ have a slender single head but about a centimeter below the proximal end there is developed a thin triangular process which extends backward over the next following rib, and the point even reaches nearly to the second rib following. Below this process the ribs are flattened for some distance but gradually assume the rounded form again. In more posterior ribs, perhaps posterior dorsals, the head of the rib is widely expanded and thin; it contracts rapidly, and about a centimeter below the head there is given off a process to the rear as in the anterior ribs, but now the process is very slender and slants inward as well as backward. The rib is flattened proximally, more rounded distally.

Measurements.	mm.
Length of the humerus	54
Length of the radius	41
Length of the scapula (approximate)	60
Length of an anterior dorsal rib	45
Length of a posterior dorsal rib	35

This animal shows a simple phase of the armor assumed by the amphibians, probably in correlation with the development of the powerful dentition of the Dimetrodonts. The position of the plates in *Trimerorhachis* is unknown, but they were large and probably lateral in position; *Dissorophus* well deserved Cope's name of a "batrachian armadillo"; in *Zatrachys* the armor was just beginning, perhaps, and was limited to the mid-dorsal line, the development of processes on the ribs, and the flattening of the ribs themselves must have been something of an element of defense. In neither *Z. apicalis* nor *Z. crucifer* are the dermal plates known; their existence is inferred from the condition of the neural spines which are sculptured with the same sort of pittings as occur in the specimen here described. It may be that the spines were unprotected by plates, in which case it will be necessary to give this form a new generic name.

59.57, 96 A: 15.3

Article XXXI.— THE FUNGUS-GROWING ANTS OF NORTH AMERICA.

By William Morton Wheeler.

Plates XLIX–LIII.

Introduction.

Among the multitudinous activities of insects, none are more marvellous than the fungus-growing and fungus-eating habits of the Attiine ants. Not only are these habits of interest as a most unusual specialization in diet—for all ants were originally and many are still exclusively entomophagous—but the successful cultivation of such delicate plants as fungi presupposes an astonishing range and complexity of adaptation even for these very plastic insects. This statement will be endorsed by those who have tried to obtain pure cultures of fungi either in the hot-house or the laboratory. Besides the selection of proper culture media and the accurate regulation of temperature and moisture, exquisite precautions have to be taken to exclude the germs of alien species. The Attii are able to achieve all this and, what is equally remarkable, at least two other groups of insects, namely, certain Old World termites and the "ambrosia beetles" (Tomicine Scolytidæ) of both hemispheres, have independently developed analogous habits.

The fungus-growing ants all belong to a single Myrmicine tribe, the Attii, and all the species of this tribe are fungus-growers. They are, moreover, confined almost exclusively to tropical and subtropical America, only a single species being known to range as far north as New Jersey. And since a few others occur as far south as Argentina, we may say that the geographical distribution of the tribe extends from 40° north to 40° south of the equator. About one hundred species, subspecies and varieties of Attii have been described and have been distributed among various genera and subgenera, as follows:

Genus *Atta* Fabricius.

Subgenus *Atta* sensu stricto, including: *A. cephalotes* L. with the vars. *lutea* Forel, *opaca* Forel, *polita* Emery and *integrior* Forel; *sexdens* L., with the subsp. *vollenweideri* Forel; *lævigata* F. Smith; *columbica* Guérin; *insularis* Guérin; *fervens* Drury; *texana* Buckley.

Subgenus *Mœllerius* Forel, including: *M. heyeri* Forel; *striata* Roger;

silvestrii Emery; *balzani* Emery; *landolti* Forel; *versicolor* Pergande with the subsp. *chisosensis* Wheeler.

Subgenus *Acromyrmex* Mayr, including: *A. subterranea* Forel; *lobicornis* Emery and its var. *ferruginea* Emery; *lundi* Guérin; *ambigua* Emery; *pubescens* Emery with the subsp. *bonariensis* Emery and *decolor* Emery; *emilii* Forel; *octospinosa* Reich with the var. *echinatior* Forel; *mœlleri* Forel with the vars. *panamensis* Forel and *meinerti* Forel, and the subsp. *modesta* Forel with the var. *andicola* Forel; *coronata* Forel; *mesonotalis* Emery; *discigera* Mayr; *muticinoda* Forel with the var. *homalops* Emery; *nigra* F. Smith; *aspersa* F. Smith with the var. *rugosa* F. Smith; *laticeps* Emery; *boliviensis* Emery; *iheringi* Emery.

Subgenus *Trachymyrmex* Forel, including: *T. urichi* Forel with the subsp. *fusca* Emery; *pruinosa* Emery; *septentrionalis* McCook with the var. *obscurior* Wheeler; *turrifex* Wheeler; *arizonensis* Wheeler; *jamaicensis* Ern. André; *saussurei* Forel; *squamulifera* Emery; *farinosa* Emery.

Subgenus *Mycetosoritis* Wheeler, including: *M. hartmanni* Wheeler; *aspera* Mayr.

Subgenus *Mycocepurus* Forel, including: *M. göldii* Forel, *smithi* Forel with the vars. *tolteca* Wheeler and *borinquenensis* Wheeler.

Genus *Cyphomyrmex* Mayr.

C. rimosus Spinola with the subsp. *minutus* Mayr, *salvini* Forel, *dentatus* Forel, *transversus* Emery and *olindanus* Forel, and the vars. *major* Forel, *fusca* Emery and *comalensis* Wheeler; *parallelus* Emery; *olitor* Forel; *auritus* Mayr; *morschi* Emery; *simplex* Emery; *strigatus* Mayr; *wheeleri* Forel; *kirbyi* Mayr; *flavidus* Pergande; *championi* Forel; *foxi* Ern. André; *bigibbosus* Emery.

Genus *Myrmicocrypta* F. Smith.

M. squamosa F. Smith; *dilacerta* Forel with the subsp. *cornuta* Forel; *subnitida* Forel; *godmani* Forel; *brittoni* Wheeler.

Genus *Sericomyrmex* Mayr.

S. opacus Mayr; *aztecus* Forel; *saussurei* Emery.

Genus *Apterostigma* Mayr.

A. pilosum Mayr; *scutellare* Forel; *mœlleri* Forel; *wasmanni* Forel; *urichi* Forel; *mayri* Forel; *collare* Emery; *robustum* Emery.

The various subgenera included under *Atta* sensu lato will probably be raised eventually to generic rank. The subgenus *Atta* comprises the leaf-cutting or parasol ants, the largest and most powerful species of the tribe, living in great colonies and inhabiting the territory between 30° north and 30° south of the equator. The workers are highly polymorphic and much smaller than the males and females. The colonies of the species of *Mœllerius* and *Acromyrmex* are much less populous, and the workers, though variable in size, do not exhibit such marked polymorphism as those of *Atta* s. str. In *Trachymyrmex* and the remaining subgenera the workers are monomorphic and but little smaller than the males and females, and the colonies are even feebler than those of *Acromyrmex*. *Mycetosoritis* and *Mycocepurus* are in certain respects transitional to the genera *Cyphomyrmex* and *Myrmicocrypta*, and species of the last show affinities with *Sericomyrmex*. *Apterostigma* is very aberrant, resembling in form certain Myrmicines of the subgenera *Aphænogaster* and *Ischnomyrmex*. The workers of *Atta* are covered with stiff, erect or suberect, hooked or curved hairs, and the surface of the body is tuberculate or spinose. In *Cyphomyrmex* the body is smoother and covered with short, appressed, scale-like hairs. In *Sericomyrmex* and *Apterostigma* the hairs are soft, flexuous and very abundant. With few exceptions all the Attii have the surface of the body opaque and of a ferruginous, brown or blackish color. All the species, moreover, though very powerful and able to make surprisingly extensive excavations in the soil, are very slow and stolid in their movements. The sting of the workers is vestigial, but in the larger species the sharp jaws may be used as most efficient organs of defence. The smaller species are extremely timid and when roughly handled "feign death" like Curculionid beetles. In all the species the hard, rough or spinose integument must afford efficient protection from alien ants and other enemies.

Owing to the labors of Forel, Emery and Mayr our knowledge of the taxonomy of the Attii is probably as satisfactory as that of any other groups of exotic ants. As much cannot, however, be said of our knowledge of the habits. Since all the Attii live in intimate symbiosis with fungi, a complete study of the habits of these insects requires the diligent coöperation of the entomologist and botanist. Hitherto the botanists, notably Alfred Mœller and Jakob Huber, have contributed the most accurate observations. As neither the botanists nor the entomologists of North America have shown any very serious interest in the Attii, I need not apologize for publishing the

following pages. Though these contribute little towards a solution of many of the outstanding problems, they nevertheless contain a number of observations that may be of permanent interest and value. My attention was first attracted to these insects several years ago while I was sojourning in Texas. It was, in fact, the sight of a leaf-bearing file of *Atta texana*, moving along the bank of Barton Creek near Austin, one sultry afternoon in September, that first kindled my interest in the habits of ants. I postponed publishing my notes on this and other species, hoping to have an opportunity to study a greater number of forms in the heart of the tropics, but as there is no immediate prospect of my being able to continue the work in these regions, I have decided to publish my observations as they stand. The present article is divided into four parts, namely, a résumé of the writings of previous students of the Attii, a taxonomic revision of the known North American members of the group, including a few from Mexico and the West Indies, an account of my own observations on these same forms, and a general consideration of some of the main problems involved in the study of the fungus-growing instincts not only in the Attii but also in the termites and ambrosia beetles.

Part I. Historical.

The large leaf-cutting ants of the genus *Atta* s. str. are such conspicuous, widely distributed, and destructive insects in tropical America that they must have been only too familiar to the indigenes and the early settlers in those regions. That these ants figured prominently in the Indian mythologies is indicated by a passage in the Popul Vuh, a collection of Guatemalan traditions to which my friend Mr. F. Bandelier has called my attention.[1] This collection was made by Dominican friars, probably during the middle or latter half of the sixteenth century. The following myth refers to the larger species of *Atta* which are known to collect the petals and whole flowers as well as the leaves of plants. The mythical young men, Hunahpu and Xbalanqué, had been taken in ambush and required by their captors, Hun-Camé and Vukub-Camé to fetch four vases of certain flowers as a test, and to forfeit their lives in case of failure. "Thus they stayed in the House of the Lances during the night, when they called on all the ants: "Cutting ants and zampopos,[2] come and together fetch the flowers designated by the princes."

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[1] Popul Vuh. Livre Sacré et les Mythes de l' Antiquité Americaine avec les Livres Héroiques et Historiques des Quichés, par L' Abbé Brasseur de Bourbour. Paris, Aug. Durand, 1861.

[2] *Zanic* is the generic name of the ant. *Chequen-zanic* is a large ant which goes about at night cutting the stems of vegetables and tender flowers, as if with scissors. Its name among the Hispano-Guatemalan peoples is *zampopo*. (Commentator's note.)

"Very well," they replied. Then all the ants set out to fetch the flowers of the garden of Hun-Camé and Vukub-Camé. These had apprised the guardians of the flowers of Xibalba in advance: "As to you, give heed to our flowers; do not let these two young men, whom we have taken in ambush, carry off any of them. Where else could they go to get those we have designated? There are none elsewhere. Watch closely therefore throughout the night."— "It is well," they replied.

"But the sentinels of the garden heard nothing of what was going on. In vain they went about, walking on their legs, among the branches of the trees of the garden, and repeating the same song. "Xpurpurek, Xpurpurek! sang one.— "Puhuyu, puhuyu!" repeated the other.

"Puhuyu was the name of the two sentinels of the plantations of Hun-Camé and Vukub-Camé. But they did not notice the ants stealing away what had been committed to their charge, going and coming in innumerable hordes, cutting down the flower beds, moving along with the flowers which they bore away in their jaws above the trees, while under the trees the flowers exhaled a sweet odor.

"Meanwhile the sentinels kept shouting with all their might, without noticing the teeth that were sawing at their tails and wings.[1] There was a harvest of flowers mown down by their jaws and borne all odoriferous by their jaws into the House of the Lances.

"Very soon the four vases were filled with flowers, and they were quite full when the day dawned. Soon thereafter the messengers came to seek them. "Let them come," said the King, "and let them bring forthwith what we have demanded," said they to the young men.

"Very well," said they. Thereupon they proceeded to fetch the four vases of flowers. Then, having presented themselves before the king and the princes, these took the flowers whose sight it was a pleasure (to behold). Thus were those of Xibalba tricked.

"It was the ants alone who had been dispatched by the young men, and who in a single night had carried away all the flowers and placed them in the vases. At this sight all the (princes) of Xibalba changed color and their faces paled on account of the flowers.

"Then they sent the men to seek the guardians of the flowers: "Why did you permit our flowers to be stolen. Are these not our own flowers which we here behold?" said they to the guardians.— "We did not notice anything, my lord. They did not even spare our tails," they replied. Then they split the lips of the guardians, to punish them for having permitted the theft of that which was committed to their charge.

[1] The commentator states that he is unable to understand this allusion. The guardians are evidently conceived as birds, as shown by the above reference to their "walking on their legs," although this is not clearly stated till the end of the passage.

"It was in this manner that Hun-Camé and Vukub-Camé were vanquished by Hunahpu and Xbalanqué, and this was the beginning of their labors. Thenceforth, too, the Purpueks had their mouths cleft, and cleft they are to this day." [1]

I am also indebted to Mr. Bandelier for the following extracts from the early historians of the Conquest. Gonzalo Fernandez de Oviedo y Valdes in his 'Historia de las Indias' (1535) gives an account of the pernicious ants and termites of Española (Santo Domingo). Among the former are certain species "which do very great damage throughout the island, in the plantations, destroying and burning up the cane and oranges and other useful plants." These ants must have been the large species of *Atta*, probably *A. insularis*, which does great damage to plantations also in the adjacent island of Cuba.

P. Bernabè Cobo, in his 'Historia de Neuvo Mundo' (1653) also describes a number of noxious ants in Santo Domingo. He says: "There is another kind of large ants which the Chiriquan Indians call Iczau, and it is these which eat the trees and whose young, when newly hatched, are called Icza, and are eaten by the Indians." These Iczau are evidently the virgin females of *Atta*. They are also eaten by the Brazilian Indians who call them Iças, according to von Ihering (1894). Cobo seems to be the first author to record the use of the heads of *Atta* soldiers by the Indians for surgical purposes: "They use a certain species of the said ants, because they bite severely, for closing wounds instead of stitching them with a needle. This is done in the following manner: they bring together the skin of the two sides of the wound and apply these ants, which bite and hold the two sides or lips together and then they cut off the insects' heads, which remain attached to the wound with their mouths or mandibles as firmly closed as they were in life."

Specimens of the large *Attæ* were, of course, taken to Europe by the early travelers. Seba (1734–35) gives a good figure of a soldier of *A. cephalotes* or *sexdens* which found its way into his collection. Linné described both of these species, and they were also known to Fabricius and Latreille. The latter authors, apparently misled by the accounts of Mlle. Merian (1771), confounded the habits of these ants with those of the "fourmis de visites," or *Ecitons*.

The first naturalist to publish observations on any of the North American Attii was Buckley (1860), who studied the habits of *Atta texana* at Austin, Texas. He was evidently under the impression that this ant eats the leaves, berries, etc., which it carries into its nests. He unearthed some of the

[1] Here the guardians pass into the domain of fable; they become night birds, the one called Purpuek, the other Puhuy, which is a species of owl; at the present time the former is pronounced Parpuek. (Commentator's note.)

nests and describes the "soft grey spongy substance, apparently leaves, finely triturated and mixed with an animal secretion," found in the chambers. This "animal secretion" was undoubtedly the web of fungus hyphæ which binds the leaf particles together.

Bates (1863) in his classical 'Naturalist on the Amazon' gives an excellent account of *Atta cephalotes*, one of the ants called "Saubas" by the Brazilians. He described the extensive earthworks of this species, "large mounds of earth of a different color from the surrounding soil, which were thrown up in the plantations and woods. Some of these were very extensive, being forty yards in circumference, but not more than two feet in height..... The difference in color from the superficial soil of the vicinity is owing to their being formed of the subsoil, brought up from a considerable depth." He describes the manner in which the ants cut out pieces of leaves and the ensuing damage to cultivated trees and shrubs, and believes that "the leaves are used to thatch the domes which cover the entrances to their subterranean dwellings, thereby protecting from the deluging rains the young broods in the nests beneath." This erroneous inference was derived from seeing the workers "troop up" and cast their pieces of leaves on the hillocks of the nest where some of them are often covered by the earth brought up by the excavating workers. Bates also records the following observation to show the extent of the subterranean burrows of the Sauba: "The Rev. Hamlet Clark has related that the Saüba of Rio de Janeiro, a species closely allied to ours, has excavated a tunnel under the bed of the river Parahyba, at a place where it is as broad as the Thames at London Bridge. At the Magaory rice mills, near Para, these ants once pierced the embankment of a large reservoir: the great body of water which it contained escaped before the damage could be repaired. In the Botanic Gardens at Para, an enterprising French gardener tried all he could think of to extirpate the saüba. With this object he made fires over some of the main entrances to their colonies and blew the fumes of sulphur down the galleries by means of bellows. I saw the smoke issue from a great number of outlets, one of which was 70 yards distant from the place where the bellows were used." This ant not only does great damage to the foliage but also plunders stores of vegetable provisions such as farina or mandioca meal in houses at night. Bates observed the division of labor among the castes although he did not accurately define the soldier, or worker major. From the fact that the latter are often seen to be simply stalking about, he concluded that their "enormously large, hard and indestructible heads may be of use in protecting them against the attacks of insectivorous animals. They would be, in this view, a kind of 'pièces de resistance,' serving as a foil against onslaughts made on the main body of workers." Had Bates undertaken to excavate a large colony of

these ants he would soon have discovered that these soldiers have a very important function to perform in the active defence of their fellow ants.

Lincecum in 1867 recorded a number of observations on *Atta texana* which, like his other publications on ants, are a strange jumble of truth and fiction. He states rather positively that this ant eats the vegetable substances which it collects. "In my observations on the habits of the cutting ants, I have not discovered them eating anything besides the foliage of various plants. Neither have I ever noticed them carrying anything else into their cities. Professor S. B. Buckley, who is a very close and accurate observer [sic!] states that he saw them carrying hackberries (*Celtis occidentalis*) and that they eat insects, tumble bugs, etc.... From the immense quantities of leaves collected by them during the autumnal months, which are carefully sun-dried and taken into the city, I should feel at a loss to say, if they are not intended for winter food, what other use they can put such quantities of leaves to; and furthermore, when it is known to be the kind of food upon which they subsist." It is interesting to note that while Lincecum overlooked the marvellous fungus-raising habits of *Atta texana* he nevertheless attributed to them certain horticultural interests: "The cutting-ants plant seeds of various trees, vines and other plants. When they locate a city in a bald prairie, which is often the case, where they cannot procure the seeds of trees, they cultivate the prickly poppy (*Argemone Mexicana*) the most appropriate plant for their purpose that grows in the prairie.... When the ants locate a city on some sunny point near the timbered lands, they do not plant the poppy, but appear to prefer certain trees and vines for shade. For this purpose they plant the seeds of the prairie dogwood (*Viburnum dentatum*), Yopon (*Ilex vomitoria*), Hackberry tree (*Celtis occidentalis*), Gum elastic tree (*Bumelia lycioides*), the mustang grape (*Vitis Texana*), *Cocculus Carolina* and occasionally the prickly ash (*Xanthoxylum fraxinum*)." While there can be little doubt that various herbs, shrubs, or even trees may spring up from the seeds collected and dropped by the ants on the soil of their nests, it is absurd to say that such seeds are actually planted with an awareness that they will ultimately grow and produce shade. Lincecum here repeats the error which he promulgated in regard to the harvesting ants of Texas (*Pogonomyrmex molefaciens*).

Norton (1868) gave a good general description of the Mexican *Atta fervens*, but made no observations on its fungus gardens.

In 1870 B. R. Townsend studied *A. texana* at Austin, Texas. Concerning the leaves collected by this ant he says: "These leaves are conveyed through these underground passages to their homes and deposited in one of their chambers, and, I presume, they secrete some substance that they put with the leaves, for if a handful of the leaves is taken in the hand and squeezed,

a ball is made very much resembling coarse bees wax, and when dried is as hard as dry putty. I judge the leaves by their decay produce a gentle heat, or, at least, maintain a uniform temperature whereby the eggs are hatched. Formerly it was suggested that these leaves constituted a store of food, but such is not the case. Whether they feed upon vegetable or animal food I cannot say."

A new epoch in the study of the fungus growing ants was inaugurated by Belt in 1874 in his interesting volume, 'The Naturalist in Nicaragua.' He was the first to surmise the use to which the leaves, etc., are put by the species which he studied (probably *A. cephalotes*). As his work has become rather rare, I quote the pertinent passages in full: "Notwithstanding that these ants are so common throughout tropical America, and have excited the attention of nearly every traveller, there still remains much doubt as to the use to which the leaves are put. Some Naturalists have supposed that they use them directly as food; others, that they roof their underground nests with them. I believe the real use they make of them is as a manure, on which grows a minute species of fungus, on which they feed; — that they are, in reality, mushroom growers and eaters. This explanation is so extraordinary and unexpected, that I may be permitted to enter somewhat at length on the facts that led me to adopt it. When I first began my warfare against the ants that attacked my garden, I dug down deeply into some of their nests. In our mining operations we also, on two occasions, carried our excavations from below up through very large formicariums so that all their underground workings were exposed to observation. I found their nests below to consist of numerous rounded chambers, about as large as a man's head, connected together by tunnelled passages leading from one chamber to another. Notwithstanding that many columns of the ants were continually carrying in the cut leaves, I could never find any quantity of these in the burrows, and it was evident that they were used up in some way immediately they were brought in. The chambers were always about three parts filled with a speckled, brown, flocculent, spongy-looking mass of a light and loosely connected substance. Throughout these masses were numerous ants belonging to the smallest division of the workers, which do not engage in leaf-carrying. Along with them were pupæ and larvæ, not gathered together, but dispersed, apparently irregularly, throughout the flocculent mass. This mass, which I have called the ant-food, proved, on examination to be composed of minutely subdivided pieces of leaves, withered to a brown color, and overgrown and lightly connected together by a minute white fungus that ramified in every direction throughout it. I not only found this fungus in every chamber I opened, but also in the chambers of the nest of a distinct species that generally comes out only in the night-time,

often entering houses and carrying off various farinaceous substances, and does not make mounds above its nests, but long winding passages, terminating in chambers similar to the common species and always, like them, three parts filled with flocculent masses of fungus-covered vegetable matter, amongst which are the ant-nurses and immature ants. When a nest is disturbed, and the masses of ant-food spread about, the ants are in great concern to carry away every morsel of it under shelter again; and sometimes, when I dug into a nest, I found the next day all the earth thrown out filled with little pits that the ants had dug into it to get out the covered up food. When they migrate from one part to another, they also carry with them all the ant-food from their old habitations. That they do not eat the leaves themselves I convinced myself, for I found near the tenanted chambers, deserted ones filled with the refuse particles of leaves that had been exhausted as manure for the fungus, and were now left, and served as food for larvæ of *Staphylinidæ* and other beetles.

"These ants do not confine themselves to leaves, but also carry off any vegetable substance that they find suitable for growing fungus on. They are very partial to the inside white rind of oranges, and I have also seen them cutting up and carrying off the flowers of certain shrubs, the leaves of which they have neglected. They are very particular about the ventilation of their underground chambers, and have numerous holes leading up to the surface from them. These they open out or close up, apparently to keep up a regular degree of temperature below. The great care they take that the pieces of leaves they carry into the nest should be neither too dry nor too damp, is also consistent with the idea that the object is the growth of a fungus that requires particular conditions of temperature and moisture to ensure its vigorous growth. If a sudden shower should come on, the ants do not carry the wet pieces into the burrows, but throw them down near the entrances. Should the weather clear up again, these pieces are picked up when nearly dried, and taken inside; should the rain, however, continue, they get sodden down into the ground, and are left there. On the contrary, in dry and hot weather, when the leaves would get dried up before they could be conveyed to the nest, the ants, when in exposed situations, do not go out at all during the hot hours, but bring in their leafy burdens in the cool of the day and during the night. As soon as the pieces of leaves are carried in they must be cut up by the small class of workers into little pieces. I have never seen the smallest class of ants carrying in leaves; their duties appear to be inside, cutting them into smaller fragments, and nursing the immature ants. I have, however, seen them running out along the paths with the others; but instead of helping to carry in the burdens, they climb on the top of the pieces which are being carried along

by the middle-sized workers, and so get a ride home again. It is very probable that they take a run out merely for air and exercise. The largest class of what are called workers are, I believe, the directors and protectors of the others. They are never seen out of the nest, excepting on particular occasions, such as the migration of the ants, and when one of the working columns or nests is attacked; they then come stalking up, and attack the enemy with their strong jaws. Sometimes, when digging into the burrows, one of these giants has unperceived climbed up my dress, and the first intimation of his presence has been the burying of his jaws in my neck, from which he would not fail to draw the blood."

During his study of *Atta* in the province of Rio Grande de Sul, Brazil, Fritz Müller appears to have reached independently the same conclusion as Belt. A letter directed to Charles Darwin and published in 'Nature' during 1874 contains the following remarks: "As to the leaf-cutting ants I have always held the same view which is proposed by Mr. Belt, viz. that they feed upon the fungus growing on the leaves they carry into their nests, though I had not yet examined their stomachs. Now I find that the contents of the stomach are colorless showing under the microscope some minute globules, probably the spores of the fungus. I could find no trace of the vegetable tissue which might have been derived from the leaves they gather; and this I think, confirms Mr. Belt's hypothesis."

Although observations on the habits of the Attii continued to be published from time to time the suggestions of Belt and Müller were either overlooked or ignored for nearly twenty years. In his studies on *Atta texana,* which, like those of Buckley, Lincecum and Townsend, were carried on at Austin, Texas, McCook (1879*a*, 1879*b*, etc.) accurately described the formicaries and fungus gardens. He found the nests to consist of several chambers or pockets, sometimes as much as 2 ft. 10 inches long, 12 inches broad and 8 inches high. The fungus gardens within these chambers are correctly described as "masses of a very light, delicate leaf-paper wrought into what may be properly called 'combs.' Some of the masses were in a single hemisphere, filling the central part of the cave, others were arranged in columnar masses 2½ inches high, in contact along the floor. Some of these columns hung, like rude honeycomb or wasp nests from roots which interlaced the chambers. The material was in some cases of a gray tint, in others of a leaf-brown. It was all evidently composed of the fibre of leaves which had been reduced to this form within the nest, probably the joint action of the mandibles and salivary glands. On examination they proved to be composed of cells of various sizes, irregular in shape, but maintaining pretty constantly the hexagon. Some of the cells were one-half inch in diameter, many one-fourth inch, most of them one-eighth inch, and quite minute.

Large circular openings ran into the heart of the mass. Some of the cells were one inch deep; they usually narrowed into a funnel-like cylinder. Ants in great numbers, chiefly of the small castes, were found within these cells. In the first large cave opened were also great numbers of larvæ. The material was so fragile that it crumbled under even delicate handling, but a few specimens of parts of the ant's comb, with entire cells, were preserved and exhibited." Although McCook knew of Belt's opinion that these masses of triturated leaves serve merely as a culture medium for the growth of edible fungi, and even saw the film of hyphæ, he nevertheless preferred to interpret the latter as "only what might have been expected under such environment," and expressed the belief "that the ants feed upon the juices of leaves." He fully appreciated the extraordinary excavating powers of *A. texana*. "The ability of these emmet masons to excavate vast halls and subterranean avenues is remarkable. Several holes in the vicinity of Austin were visited, out of which 'beds' or nests of ants had been dug by an old man who used to follow the business of ant killing. These holes were nearly as large as the cellar for a small house. One such excavation, about three miles from Austin, was 12 feet in diameter and 15 feet deep. At the lowest point had been found the main cavity, quite as large as a flour barrel, in which were found many winged insects, males and females, and quantities of larvæ. This nest was situated 669 feet from a tree that stood in the front yard of a house which the ants had stripped." McCook examined and reconstructed the tunnel excavated by the ants in order to reach this point and found that although its course varied from 18 inches to 6 feet below the surface it deviated little from a direct line and gave off a couple of branch tunnels to a peach orchard 120 feet distant.

In 1880 Morris studied the habits of a small Attiine ant (*Trachymyrmex septentrionalis*) which he had discovered near the village of Tom's River on Barnegat Bay, New Jersey. During December of the same year McCook communicated this discovery to the Philadelphia Academy of Sciences and during the following year (1881) Morris published his own observations in the 'American Naturalist.' Both authors regarded the fungus-gardens as subterranean "combs" adapted for incubating the brood. Morris saw the ants carry in and incorporate into their fungus gardens the leaves of seedling pines, the flowers of cow wheat (*Melampyrum americanum*) and "the droppings of certain larvæ that feed on oak-leaves." The nest is described by both authors and figured by McCook as consisting of two spherical chambers, one above the other and connected by a short gallery. The entrance was oblique and about 2 inches in length. The upper chamber was 1½ inches in diameter, the lower 3 inches. The former was empty, the latter contained the "combs" suspended from rootlets that had been left

intact while the ants were excavating the chamber. Morris's description of these "combs" is more accurate than McCook's.

Brent in 1886 described the nesting habits, etc., of the large *Atta cephalotes* of Trinidad: "A good sized mango tree, at least as large as an average apple tree, I saw stripped of every leaf in one night, and greater feats than this are recorded of these 'Fourmi Ciseaux,' as they are called by the Creoles." Brent gives a diagram of the nest and describes a tunnel leading from the lowermost fungus-chamber to a still lower level. He "invariably found this lower tunnel wherever the inclination permitted its construction" and has "no doubt that it is constructed as a drain, and that the ants know as much about the advantage of thorough drainage as they have been proved to know, by many eminent observers, of those of other sanitary matters." Some of the chambers of the nest are described as 3 feet in diameter. He mentions Amphisbænians as living in the nest and eating the ants. In regard to the use to which the leaves are put, Brent says: "A solution of arseniate of soda was next sprinkled upon orange leaves, which were strewn upon the mound. These were eventually cleared away, although at an immense sacrifice of life. This points, I think, to the true ant food, since unless the juices of the leaves as they were sawed up were swallowed, the poison would have no effect. This idea is strengthened by the fact that fiery and strongly aromatic plants as well as those with poisonous, milky juices are carefully avoided. No solid food is found in the crops of the insect at any time, but if these are examined after the insects have been engaged in leaf-cutting, they are found full of green leaf juice." Later he says: "The larvæ are embedded in a soft woolly matter which proved to be the finely masticated parenchyma of the leaves. Thus a use was found for the leaves, although it reflects seriously upon the supposed sagacity of the ants that they should procure so many more than are required for the purpose."

Emery (1890) appended a brief ethological note to his description of *Acromyrmex landolti* of Caracas, Venezuela. Simon wrote him that "this ant makes extensive formicaries with several entrances, each surmounted by a column or chimney of straws 10–15 cm. high, in which lives a large spider of the genus *Ctenus*. Simon never saw the ants carry in pieces of leaves like *Atta sexdens* and believes that they confine themselves to collecting pieces of dried grasses."

Observations on *A. cephalotes* in Trinidad were resumed in 1892 by Tanner in two important papers, which, owing to their publication in an obscure serial, have been overlooked by subsequent students. He was the first to study Attii in artificial nests and to prove that not only the adult ants but also the larvæ feed on fungus hyphæ. In his first paper (1892*a*) he describes the manner in which the workers triturate the leaves: "Each

forager drops the portion of the leaf in the nest, which is taken up as required by the small workers, and carried to a clear space in the nest to be cleaned. This is done with their mandibles, and if considered too large it is cut into smaller pieces. It is then taken in hand by the large workers, who lick it with their tongues. Then comes the most important part, which almost always is done by the larger workers, who manipulate it between their mandibles, mostly standing on three legs. The portion of the leaf is turned round and round between the mandibles, the ant using her palpi, tongue, her three legs and her antennæ while doing so. It now becomes a small almost black ball, varying in size from a mustard seed to the finest dust shot, according to the size of the piece of the leaf that has been manipulated. The size of the piece of the leaf is from $\frac{1}{8}$ by $\frac{1}{8}$ of an inch, to $\frac{1}{4}$ by $\frac{1}{4}$ of an inch. I do not wish it to be understood that only one class of workers manipulate the leaf, for all seem to take to it very kindly on emergency. Even the smallest workers will bring their tiny ball to where the fungus bed is being prepared. These balls, really pulp, are built on to an edge of the fungus bed by the larger workers, and are slightly smoothed down as the work proceeds. The new surface is then planted by the smaller workers, by slips of the fungus brought from the older parts of the nest. Each plant is planted separately and they know exactly how far apart the plants should be. It sometimes looks as if the plants had been put in too scantily in places, yet in about 40 hours if the humidity has been properly regulated, it is all evenly covered with a mantle as of very fine snow. It is the fungus they eat, and with small portions of it the workers feed the larvæ."

In his second paper, published the same year (December, 1892), Tanner describes the eggs and larvæ of *A. cephalotes* and the method of feeding the latter, together with certain observations which go to show that workers lay eggs capable of developing into other workers or even queens. The eggs become enveloped in a "pearly white fluffy growth." The larvæ which hatch from these eggs "are usually placed on the top of the nest and are constantly attended by the smallest workers — the nurses — who separate them into divisions according to their size. At first it seemed a mystery, how these minute grubs could be fed so systematically, knowing that each individual larva was only one among so many, yet certain it was, that all were equally attended to. Further observations showed that nature had provided most efficiently for them to ask for food when they required it. This the larvæ do by pouting their lips; at this notification of their requirement the first nurse who happens to be passing stops and feeds them. The nurses are continually moving about among them with pieces of fungus in their mouths ready for a call for food. The nurses feed the minute larvæ by merely brushing the fungus across their lips showing that the spores

alone are sufficient for its food at that period of its life. But it is not so when the larvæ have increased so much in size, that the pout can be seen without a glass, for then the whole piece after having been manipulated by the nurse's mandibles into a ball, in the same manner as the leaves are served, when they are first brought into the nest, is placed in its throat and if that is not sufficient the pout continues when the next one and even the next passing proceeds with the feeding, till the pout is withdrawn, showing that it is satisfied. No further notice is then taken of it by the feeders, until it agains asks for a meal by pouting later on in the day."

In 1893 a nephew of the celebrated Fritz Müller, Alfred Mœller, who was given a grant of 5,000 marks by the Berlin Academy of Sciences for the purpose of studying the habits of the Attii at Blumenau in the province of Rio Grande do Sul, published the most important of existing works on these insects and their relations to the fungi which they cultivate. He studied several species of *Atta* belonging to the subgenus *Acromyrmex* (*discigera, coronata, octospinosa, mœlleri*) and of the genera *Apterostigma* (*pilosum, mœlleri, wasmanni,* and an undetermined species) and *Cyphomyrmex* (*auritus, strigatus*). *A. octospinosa* and *discigera,* which nest in the woods, form truncated cones of dead leaves and twigs, beneath which they excavate a single chamber containing a large fungus garden sometimes 1½ meters long. *A. mœlleri* has similar habits, but *coronata* resembles the species of the subgenus *Atta* s. str. in forming several chambers, each with its own fungus garden. In all of these species the garden is built up on the floor of the chamber in the form of a loose sponge-work of triturated leaf-fragments permeated with fungus hyphæ which he describes as follows: "Over all portions of the surface of the garden are seen round, white corpuscles about ¼ mm. in diameter on an average, although some of them are fully ½ mm. and sometimes adjacent corpuscles fuse to form masses 1 mm. across and of irregular form. After a little experience one learns to detect these corpuscles with the naked eye as pale, white points which are everywhere abundant in all the nests. Under the lens they sometimes have a glistening appearance like drops of water. They are absent from the youngest, most recently established portions of the garden, but elsewhere uniformly distributed, so that it is impossible to remove with the fingers a particle too small to contain some of the white bodies. I call these the 'kohlrabi clusters' of the ants' nests. They constitute the principal, if not the only food of the species of *Atta*." These clusters are made up of the "heads of Kohlrabi," which are small terminal dilatations of the hyphæ of a spherical or oval form. Mœller confirmed Belt's observations on the solicitude of the ants for their gardens, and showed that these insects in artificial nests will completely rebuild these structures within 12 hours after they have been disintegrated

or scattered. He also saw the ants eating the fungus and was able to satisfy himself that the different species of *Atta* will eat the Kohlrabi from one another's colonies but not that of *Apterostigma* or *Cyphomyrmex*. He gives the following interesting description of the way in which the leaves are comminuted by the workers. "The manipulation of the pieces of leaves is the same in all the *Atta* species and the following description holds good uniformly for all of them. The ant first cuts the leaf it has brought in through the middle and then busies itself with only one of the halves, cutting off another piece, and so on. When the piece of leaf which it has retained is sufficiently small so that it can be turned round and round between its fore-feet with the aid of its jaws, it is felt of on all sides and turned in all directions as if the insect wished to get a clear idea of its form. Then an even smaller piece is cut off and this is repeated, till the piece that is retained is hardly longer than the ant's head. The rejected pieces are picked up by other workers and treated in the same manner. Then the ant holds the little piece between its fore-feet with the sharp edge directed towards its mouth and begins to pinch its edges at short intervals around the circumference without ever cutting through the substance. The piece thus manipulated shows fine, radial ridges under a good lens. The surface of the leaf is also abraded with the points of the mandibles, wounded, so to speak, so that it soon becomes soft. Then the ant kneads it with the feet and again inserts her jaws into the pellet thus formed in order to mould it thoroughly. Again and again the jaws close upon the pellet while the feet press it and place it in a new position, and again it is kneaded. This manipulation is carried on with great care and deliberation, and I have several times observed that an ant will spend a quarter of an hour in making such a pellet. When it has become a soft mass, the worker takes it in her jaws and seeks a suitable spot for it in the portion of the garden that is just being built. Once I saw an ant that had found such a spot, actually jab the pellet into the garden with a jerk of her head and a simultaneous opening of her jaws, and then carefully pat it down with her fore-feet. Another time a worker laid her pellet in a breach of a newly erected circular wall, and then shook and pushed it into the depression, like a mason setting the last brick in a fresh layer of mortar. During all of this work, the antennæ are continually moving and palpating the pellet just as they are while the ant is feeding." Into the new material thus added to the garden the fungus hyphæ grow very rapidly. By afternoon pellets built in during the morning hours have become permeated in all directions with mycelium. Belt supposed that the smallest workers or minims comminute the leaves and build up the fungus gardens. According to Mœller, however, this is the office of the mediæ, as the leaves are too thick to be manipulated by the smallest

workers. The latter have another function, namely that of weeding the garden and keeping down the growth of spores belonging to alien fungi. Mœller emphasizes the remarkable fact that the gardens are pure cultures although the hairy, rough-bodied workers must be continually bringing into the nest all sorts of spores and bacteria. It is probable also, that the minims are instrumental in producing the "kohlrabi heads" as these are not developed when the mycelium is grown in artificial culture media apart from the influence of the ants. He summarizes the results of this portion of his studies in the following words: "All the fungus-gardens of the *Atta* species I have investigated, are pervaded with the same kind of mycelium, which produces the 'kohlrabi clusters' as long as the ants are cultivating the gardens. Under the influence of the ants neither free aërial hyphæ nor any form of fruit are ever developed. The mycelium proliferates through the garden to the complete exclusion of any alien fungus, and the fungus garden of a nest represents in its entirety a pure culture of a single fungus. The fungus has two different forms of conidia which arise in the garden when it is removed from the influence of the ants. The hyphæ have a very pronounced tendency to produce swellings or diverticula, which show several more or less peculiar and clearly differentiated variations. One of these which has presumably reached its present form through the influence of cultivation and selection on the part of the ants, is represented by the 'kohlrabi heads'."

A number of experiments were undertaken by Mœller for the purpose of ascertaining the behavior of the fungus in the absence of the ants. Under these conditions he found that the mycelium produces aërial hyphæ, the "kohlrabi clusters" and "heads" disappear and soon the fungus breaks up into masses of bead-like conidia. "As long as the ants are active in their garden, there is never either in it or in its immediate vicinity the slightest trace of an alien fungus, and, under these circumstances, the mycelium pervading the garden never produces aërial hyphæ or conidia." If, however, a few of the ants happen to be left in the garden, the development of aërial hyphæ is retarded, and though Mœller did not observe the process directly, he is certain that these hyphæ must be bitten off by the ants as soon as they make their appearance. "A relatively very small number of workers suffices to restrain the growth of the aërial hyphæ. But if the number is too small, the aërial filaments begin to appear sporadically. The ants are unable to move about in the dense growth of sprouting filaments and have to beat a retreat before the rapidly rising hyphal forest. This, however, as soon as it has acquired a little headway, proliferates mightily, and it is an amazing sight to behold the poor insects, tirelessly active till the last moment, fleeing before their own food-plant. If some of the larvæ and pupæ

are still present, they are rescued. The last resort is the vertical wall of the glass, up which the insects creep and where they huddle together, while over the wide plain of the garden the fungus proceeds to the conidia-producing stage."

Mœller next undertook to determine the systematic position of the fungus. He naturally supposed that the discovery of the fruiting form would show it to be an asco- or basidiomycete. Although he failed to raise either of these forms from his mycelial cultures he succeeded on four occasions in finding an undescribed agaricine mushroom with wine-red stem and pileus growing on extinct or abandoned *Acromyrmex* nests. From the basidiospores of this plant which he called *Rozites gongylophora,* he succeeded in raising a mycelium resembling in all respects that of the ant gardens. Three of the species of *Acromyrmex* did not hesitate to eat portions both of this mycelium and of the pileus and stem of the *Rozites.* He believed therefore that he had definitively established the specific identity of the fungus cultivated by the ants.

The species of *Apterostigma* investigated by Mœller usually nest in cavities in rotten wood which is often also inhabited by other insects. The fine wood castings and excrement of these insects are used by the ants as material with which to construct their fungus-gardens. *A. wasmanni* constructs the largest nests, and it is only in the gardens of this species that the mycelium produces structures analogous to the "kohlrabi heads" and "clusters" of *Acromyrmex.* The heads, however, are club-shaped instead of spherical dilatations of the hyphæ. As it produces only irregular swellings on the hyphæ Mœller believes that *Apterostigma* represents a much lower stage in fungus-culture than the species of *Acromyrmex.* The *Apterostigma* are, however, very adaptable since they readily collect caterpillar excrement or even farina and incorporate these substances into their gardens. Mœller states that all the species of this genus cultivate the same fungus, which must be a distinct species as the ants will not eat the fungus grown by *Acromyrmex.* The gardens of *pilosum, mœlleri* and another undetermined *Apterostigma,* which live in small colonies of only 12 to 20 individuals, are suspended from the roofs of the small cavities, 3 to 4 cm. in diameter, in the rotten wood and exhibit a peculiar structure not seen in other *Attii.* "The garden is often completely, or at least nearly always in great part, enclosed in a white cob-web-like membrane. It was often possible to obtain a view of uninjured nests of *A. pilosum* that had been excavated in clefts of the rotten wood. In such cases the envelope enclosed the whole fungus garden like a bag with only a single orifice or entrance. The envelope is attached in a pendent position to the surrounding wood, roots or particles of earth by means of radiating fibres, and this explains why the gardens

are so easily torn asunder while the nest is being uncovered." Even in captivity these ants persisted in hanging their gardens to the sides of the glass dishes in which they were kept. "Microscopical examination shows that the envelope consists of the same, loop-like hyphæ as the remainder of the garden. Such a structure cannot be produced by the fungus except under extraneous influences. We must assume that the ants bring about the development of the envelope, that they direct or coërce the growth of individual hyphæ with their antennæ or fore legs, spread them out into a layer and bite off the recalcitrant hyphæ that grow out from the surface." Mœller succeeded in cultivating the mycelium of the *Apterostigma* gardens in artificial media, but he failed to obtain the fruiting stage. He believes, however, that the fungus is a basidiomycete.

The two species of *Cyphomyrmex* observed by Mœller were found nesting under bark or in rotten wood like *Apterostigma*. The largest gardens of *C. strigatus* are only 8 cm. long, whereas those of *C. auritus* may attain a length of 15 cm. and a breadth and height of 5 cm. These gardens are never pendent and never enclosed in a mycelial envelope. In other respects they resemble those of *Apterostigma* and are grown on the same substrata. The heads are developed as long, irregular swellings in the hyphæ and therefore represent a more primitive and imperfect stage than those of *Acromyrmex*. Although he was unable to obtain the fruiting stage, Mœller nevertheless believed that the fungus of the species of *Cyphomyrmex* is different from that cultivated by the ants of other genera. He concludes his paper with a few interesting notes on the breeding habits of the Attii. The eggs of *Acromyrmex* are laid in masses and embedded in loosely woven hyphæ which enable the ants to carry them about in packets. The pupæ, too, are often enclosed in hyphæ, but this is not the case with the larvæ which are kept clean and shining.

In 1894 von Ihering, in an interesting paper on the ants of Rio Grande do Sul, records a number of observations on Attii (*Atta sexdens, Mœllerius striatus, Acromyrmex lundi, niger* and *Cyphomyrmex morschi*). His general account of the nests of *A. sexdens* agrees with that of preceding authors who have studied the large *Attæ* s. str., and comprises also an interesting observation quoted from a former paper (1882) on the importance of these insects in reversing the position of earth strata: "A piece of pasture land had been marked off by a recently excavated ditch several feet deep. The soil in this place, as generally in the surrounding country, consisted of sand. Beneath this in many portions of the region there was a stratum of heavy red clay at a depth of four feet or more. What attracted my attention in this ditch was the fact that here the clay lay uppermost in a layer about 1 dcm. thick. The explanation of this condition was not the result of geological

but of zoölogical investigation, for closer inspection soon showed that the ants are responsible for the inversion of the normal position of the strata. It was the work of *Atta sexdens*. It is very doubtful whether such an enormous task can be accomplished by any insects except the large species of *Atta*." Von Ihering observed the marriage flight of *A. sexdens* and the digging of the nests by the recently fertilized females, an instinct manifested even by individuals whose gasters have been bitten off by birds. *A. sexdens* extends southward in Brazil only to the Cebus-line (latitude 30°) The nests of *Acromyrmex lundi* are excavated to a depth of 50–60 cm. and consist of a single chamber with a cubic capacity of ½ to 1 litre, in older nests 5 to 10 times as great. This cavity contains a single fungus garden and is connected with the surface by means of a large horizontal or tortuous gallery 1–2 m. long. From the nest-entrance, branching, well-worn roads lead off over the surface often to a distance of 40 m. and further, and it is along these that the ants travel to and from the grasses which they cut down together with their green seeds. This ant carries the exhausted portions of the fungus garden out of the nest and deposits them on a refuse heap. The same is true of *Mollerius striatus*. This species clears the ground of vegetation around its nest entrance which is surmounted by a crater. Like *A. lundi* it collects pieces of grass, flowers, leaves, etc. *A. niger* nests in thickets between the roots, where it excavates its nest at some distance from the entrance. It does not confine its cutting operations largely to grasses like *lundi* and *striatus* but attacks many other plants and is therefore of greater economic importance.

Cyphomyrmex morschi nests in the soil, where it excavates a chamber about the size of an orange and containing a fungus garden of leaf detritus covered with mycelium. The entrance is surmounted by a circular crater.

Von Ihering is one of the few who have considered the question of the origin of the fungus-raising instincts of the Attii. His remarks on this subject will be considered in the concluding portion of this article.

Urich, in two papers published during the same year (1895*a*, 1895*b*) records a number of observations on several of the Attii of Trinidad (*Atta sexdens, A. cephalotes, Acromyrmex octospinosus, Trachymyrmex urichi, Sericomyrmex opacus, Apterostigma urichi, A. mayri* and *Cyphomyrmex rimosus*). His account of the large species of *Atta* adds little of interest to that of previous authors. On two occasions he found the deälated females of *Acromyrmex octospinosus* "working just as hard and engaged in the same occupation as the neuters, viz: cutting leaves and carrying them to the nest. They all issued from the same nest and therefore could not have been mothers of new colonies." He "also noticed that several females lost their wings in the nest without any marital flight, although a few weeks later the winged ones swarmed out in the usual way on a damp evening."

The nest of *Trachymyrmex urichi* is "excavated in clayey soils and never anywhere else. It consists of one chamber at about the depth of a foot and is never directly under the entrance hole, but always on one side at right angles and about 9 inches away from it. It has a habit of carrying the particles of earth which result from its mining operations a little way from the entrance hole, say about a foot, and deposits them in a small conical heap.... These ants also cultivate a fungus and if it is not *Rozites gongylophora* it is very much like it.... Any roots of plants going through the ants' chamber are not cut away, but are made to suspend their mushroom gardens which are in their case regular hanging gardens.... They are nocturnal in habits and when disturbed sham death." They "seem to like small fallen flowers and the fruit of various kinds of plants to be found in gardens, but at the same time they do not despise rose plants, especially the young and tender shoots. They are not at all energetic and are very slow in their movements."

The habits of *Apterostigma urichi* are described as follows: "Unlike *Atta* this species does not excavate its nests but builds them in rotten trunks of trees.... They are built in hanging position, *i. e.*, the ants start working from the top, but never let the nest touch the bottom of the cavity. Unless the garden is quite recent and small it is always enclosed in a delicate white covering, which at first sight looks like fine cobweb, with an exit hole at the bottom. The nests therefore look like a more or less rounded ball and are never larger than an apple. On breaking away this delicate covering a small mushroom garden is found consisting of irregular cells in which the ants, larvæ and pupæ are scattered." The fungus is similar to that described by Mœller for the Brazilian species of *Apterostigma*. "The gardens are always found under rotten wood and the ants invariably use the excrementa of wood-boring insects as a medium for growing their fungus on.... The colonies of these ants are small, not numbering more than 20 or 30 dark brown workers, all of about the same size, viz. 6–6½ mm. and with abnormally long legs which measure 7–7½ mm. without the hip. They are of nocturnal habits." The smaller *A. mayri* constructs similar gardens in dark cavities, not only under rotten wood but also under large stones. It, too, collects the excrement of wood-boring insects, but is also fond of fruits or even parts of flowers. The mycelium has the kohlrabi aggregated into regular clusters and according to Urich represents a more advanced condition than that of *A. urichi*. The ants are nocturnal and sham death for many seconds.

Urich has also given us the only existing account of the habits of a *Sericomyrmex* (*S. opacus*). "The nests of these ants are found commonly about Port of Spain, in gardens, in the grass as a rule, but sometimes in the flower beds, and from their peculiar raised entrance can be readily recognized.

They are always excavated in clayey soil, and the raised entrances, which are more or less cylindrical, are constructed with the particles of earth resulting from their mining operations and are about an inch in height. In young colonies this entrance leads into a small chamber, about six inches below the surface of the ground, situated not at the end of the gallery but either to the left or right of it. As the colony increases the ants do not enlarge this original chamber, but, piercing its side, form another chamber near it with a small entrance hole. In large colonies, which never consist of more than about 200 individuals, a nest consists of two or three chambers which open on the original excavation. This is no longer used for growing the fungus in, but forms a sort of ante-chamber which generally contains material brought in by the ants to grow their mushrooms on, which is deposited here and gradually made use of. The chambers adjoining are more or less round, with a diameter of about 2–3 inches, and any small roots of plants growing through them are not cut away but used by the ants to hang their mushroom gardens on. These fill the interior of the chamber and consist of a gray spongy mass consisting of a great number of little irregular cells and resembling a coarse sponge, amongst which are scattered larvæ, pupæ and ants. The walls of the cells consist of small round pellets resembling dust shot and are penetrated by and enveloped in white fungus hyphæ, which hold the mass together. Strewn thickly upon the surface of the garden are to be seen round white bodies about a quarter of a millimeter in diameter. These are what Mœller terms "Kohlrabi" clumps, and consist of an aggregation of hyphæ with special swellings at their ends. It is on this that the ants feed. The fungus found by Mœller in the nests of the Brazilian fungus growers (*Acromyrmex*) is the *Rozites gongylophora*, Mœller, and if it is not the same species cultivated by *S. opacus* it is, at any rate, very nearly related to it. As material to grow their mushrooms on the ants make use of particles of fruit, flowers, and leaves, but prefer fruit. They do well in artificial nests, constructed on Sir John Lubbock's plan, and are easy to watch. I have tried them with all kinds of vegetable products; they have taken orange, banana, rose petals and leaves and once they even made use of the dried glue from the back of an old book lying near their nest, but that day they had nothing else; if the choice be left to them they invariably take fruit and seem to prefer the orange amongst these. Very small particles of the white skin of the oranges are torn off, and after undergoing a slight kneading process in the ants' mandibles, are planted in the nest. The neuters are all of the same size, varying but slightly and never exceed 4 mm. in length. They are more diurnal in their habits than other species of fungus growers,—but also work a little at night. I have found winged forms in the nests in the month of July."

Urich is responsible for the erroneous statement that *Cyphomyrmex rimosus* "does not cultivate any fungus," a statement which has been repeated by subsequent writers (Forel, Emery).

In 1896 Swingle read a paper on *Trachymyrmex septentrionalis* (= *tardigrada* auct.) before the American Association for the Advancement of Science. He says: "In July of this year I examined some colonies of *Atta tardigrada*, which Mr. Pergande had found in the vicinity of Washington. The nests are small subterranean cavities, 6–10 cm. in diameter, situated from 2 to 15 or 20 cm. below the surface. Some nests have one cavity, others two. Almost the whole cavity is filled with a grayish material loosely and irregularly connected together. By watching the ants, it was determined that they carried into their nests the excrements of some leaf-eating insect, lying on the ground under neighboring oak-trees. The same material was found to constitute at least a large part of the substance filling the nest. Even with a low magnifying lens, tufts of minute sparkling bodies could be seen on the fragments of the fungus garden, while the whole mass was interpenetrated by the white mycelium of a fungus. Examination with higher magnification showed that the glistening tufts were really composed of 'Kohlrabi' even more perfectly spherical than figured by M. Mœller. The mature 'Kohlrabi' were very much larger than the mycelium below, being 22 to 52 μ wide and 30 to 56 μ long, while the supporting mycelial threads were only 4 to 8 μ in diameter. There are no septa dividing the 'Kohlrabis' from the mycelial threads. The whole appearance of the fungus is strikingly similar to that found by Mœller, and it is by no means impossible that it will prove to be the same species though the Kohlrabis are nearly twice as large as what he reports."

Forel (1896*a–c*, 1897, 1899–1900*b*) has recorded a number of observations on the *Attii* of Colombia (*A. sexdens, cephalotes* and *lævigata*; *Acromyrmex octospinosus*, and species of *Trachymyrmex, Sericomyrmex, Mycocepurus*, and *Apterostigma*). He excavated one of the huge nests of *A. sexdens* belonging to an extensive colony at Rio Frio (1896*b*). "This nest looked like an immature volcano and consisted of a mass of 12 to 20 fused craters. The whole nest was 5 or 6 m. in diameter and about 1 m. high. The largest (median) crater was about 60 cm. in diameter, 28 cm. high, and had an opening below of about 3½ cm. The smaller accessory nests in the neighborhood (100 to 200 steps distant) had only 2–3 craters and were much smaller. There are two kinds of craters; one consisting of sand or soil of a gray color and consisting of the excavated earth, the others are brown and consist of the rejected and useless remains of the gardens, *i. e.*, the portions that have been exhausted by the fungi, thrown out in this manner in the form of brown pellets. The medium-sized workers are

seen continually coming out of the latter craters laden with brown pellets which they cast aside, while into the gray craters a stream of the same kind of workers is entering in an almost continuous procession laden with green leaves. Some small workers also stand around the openings. On disturbing the nest one is severely attacked by the largest workers. With their sharp jaws, worked by enormous muscles, they can bite so severely as to bring the blood; in fact, a small artery in my little finger was severed by one of these workers. The wounds were as much as 4 mm. in length. Nevertheless Mr. Bradbury, a native and myself attacked the nest with a shovel and dug into it deeply. Thousands of the large workers rushed out at us. The half-naked Indian ran away and I had to retreat from time to time with bleeding hands. But the interior of the nest was laid bare. This consisted of a number of great cavities, 15 to 20 cm. long and 8–12 cm. high and each was nearly always filled with a fungus garden, which looks very much like the single garden of the *Acromyrmex* species. In the labyrinth of this gray to brown garden live thousands of the smallest and medium sized workers, together with the whole ant brood. Colossal female larvæ are there found covered with a regular envelope of larvæ of all sizes, so that they have the appearance of hedge hogs. The workers held fast to the larvæ so tenaciously that I could take them in my hands and even kill them in alcohol without their losing their hold....The large species of *Atta* therefore have not only one but hundreds of fungus gardens. The fungus chambers communicate with one another by means of broad galleries 2–3 cm. in diameter. The lower portion of the garden is uniformly light rust-red with white fungus patches, whereas the upper portions are more gray. The dark brown portions seem to represent the residuum. The fungus garden is so friable that it is impossible to remove it without destroying its form. How the old myth, or nonsense, that these *Atta* species line their nests with leaves could have originated and could even be revamped by McCook is incomprehensible to me....All the pupæ are naked, that is, not enclosed in cocoons. The workers have the habit of carrying their straying sisters exactly like our species of *Formica* (the carried ant is rolled under the head of the carrier)." In another place (1899, 1900*b*) Forel says that *Acromyrmex octospinosus* carries its sister workers in the reverse position, *i. e.*, like *Myrmica*. He also describes (1896*b*) very briefly the nests and distribution of *A. cephalotes* and *lævigata*. The latter also has very large but deeply subterranean nests. It lives more in the mountains at and above an altitude of 1,000 m. and so far down in the ground that Forel could not reach the fungus gardens. *Cephalotes* is intermediate; its nests are nearly as large as those of *sexdens* and the fungus-gardens have a very similar structure and arrangement. The colonies of *cephalotes* and espe-

cially of *lævigata*, are less populous than those of *sexdens*. The nests of *cephalotes* occur from sea-level to an altitude of more than 1,000 m., those of *sexdens* only in the low-lying regions.

According to von Ihering (1898) the nest of the Brazilian *Atta sexdens* differs from that of the Colombian form described by Forel. It consists of from one to two dozen chambers, each 25–30 cm. in diameter and 12 to 15 cm. high, with a flat floor and arched ceiling. Each of these chambers, *panellas* (pots) or *pratos* (plates) as they are called by the Brazilians, has one or more, rarely two, galleries entering it at the side and connecting it with the other cavities and the vertical shafts leading to the surface of the nest. The chambers are ½ to 1 m. apart and are excavated at a depth of 4 to 6 m. below the surface or even lower. The fungus gardens are built up on the flat floors of the chambers. Von Ihering found that when the nests are inundated the ants at once remove portions of their fungus gardens to higher ground. When this is impracticable or the inundation is very great, the population of the nest forms a ball held together by the closed jaws of the workers and enclosing in its interior a portion of the fungus garden and probably also the queen. This ball then floats on the water till carried ashore, when the ants land and start a new nest out of reach of the flood. Von Ihering says that his neighbor took advantage of this habit, which by the way is also exhibited by several other tropical ants (*Anomma*, *Solenopsis geminata*, etc.), to free his premises from the leaf-cutting *Attæ*, by rowing about in his canoe, catching up the floating balls and throwing them into a bucket of boiling water. Von Ihering also gives an interesting account of the *iças*, or virgin queens of *Atta sexdens*. At the time of swarming these are captured in great numbers by the Brazilians. The içа hunter stations himself at the entrance of the nest with his feet in a tub of water in order to protect himself from the savage soldiers and workers, and collects the females while they are issuing from the galleries. A successful catch may yield as many as 12 to 20 litres. The gasters of these iças, removed from the thoraces, legs and heads and roasted with salt, garlic and mandioca meal are eaten as a delicacy (“*passoca*”) in many parts of Brazil.

Forel (1899–1900*a*, 1901) has also recorded a few notes on the fungus-gardens of a colony of *Trachymyrmex septentrionalis* which he observed at Black Mountain, North Carolina, but he adds little to the above cited descriptions of Morris, McCook and Swingle. Forel (1905) later published some notes of Gœldi on the nests of *Acromyrmex octospinosus*, the fungus gardens of which are built over the stems of plants and fully exposed to the air in the damp forests of Para. Two photographs accompanying the article show that this fungus garden consists of a number of separate portions unlike the single garden which Urich and Forel describe this ant as making when nesting in the ground.

In 1900 Moreno published some observations on the Mexican *Atta* (probably *fervens*) but these add nothing of value to what was previously known.

In 1901 I recorded a few notes on *Atta fervens* and *Cyphomyrmex rimosus dentatus* which I observed in Mexico. I was able to convince myself that the statements of Urich, Forel and Emery to the effect that the latter species makes no fungus-garden, are erroneous. This ant constructs a fungus garden with caterpillar excrement and cultivates a peculiar fungus consisting of small yellow nodules, which have been overlooked by previous investigators. More recently (1905*a*) I have found that other varieties and subspecies of *C. rimosus* in Texas, Florida, the Bahamas, Porto Rico and Culebra have the same habit. In this same paper I also described briefly the habits of *Trachymyrmex jamaicensis*, and in a subsequent paper (1905*b*) also those of *T. septentrionalis*. A fuller account of these various species will be found in the third part of the present article.

M. T. Cook (1906) has very recently studied the habits of *Atta insularis* and has published a few notes on the ravages of this ant in the plantations of Cuba.

The preceding paragraphs deal almost exclusively with observations on adult colonies of the *Attii* and the constitution and care of their fungus gardens. As soon as these habits had been demonstrated, the question naturally arose as to how the ants first come into possession of the fungi which they cultivate with such marvellous skill and assiduity. The labors of the South American naturalists Sampaio, von Ihering, Gœldi and Jakob Huber have supplied the answer to this interesting question.

Sampaio (1894) on digging up an *Atta* female ten days after the nuptial flight, found her in a cavity with two small white masses, one consisting of 50–60 eggs, the other of a filamentous substance which was the young fungus garden, though not recognized as such. Three and one half months after the nuptial flight he excavated another nest which had an opening to the surface of the soil. He found numerous workers of three different sizes but all smaller than the corresponding castes in adult colonies. They were already cutting leaves and had a fungus garden about 30 cubic centimeters in volume. He estimated the number of workers at 150 to 170, that of the larvæ and pupæ at about 150 and the eggs at 50.

The much more important observations of von Ihering (1898), including his brilliant discovery of the method of transfer of the fungus culture from the maternal to the daughter colony, deserve fuller consideration. According to this observer there are repeated nuptial flights of the Brazilian *Atta sexdens* from the end of October to the middle of December. These flights are essentially like those of other ants. On descending to the earth the

fertilized female "rids herself of her easily detached wings by quick motions of her legs and then begins to dig her burrow in some spot more or less free from vegetation. This canal is nearly or quite vertical and measures about 12–15 mm. in diameter. It is so narrow that the 'Içа' cannot turn around in it, but is compelled to walk backwards whenever she returns to the surface. She bites off lumps of earth with her powerful jaws, makes them into a pellet by means of loose threads of saliva, brings them up and deposits them a short distance from the entrance to the burrow. The earth thus brought up forms a circular wall, thickened in front and interrupted behind, about 4–5 cm. broad in front and at that point 3 cm. from the entrance. The burrow varies from 20–30 cm. in length according to circumstances and ends in a small laterally placed chamber about 6 cm. long and somewhat less in height. As soon as the chamber is completed, the ant closes the upper portion of the burrow to a distance of 8–10 cm. from the entrance with pellets of earth and this closure becomes more and more compact in the course of weeks, probably through the action of the rain. If the nest be opened in one or two days, the female will be found in the empty chamber unchanged, only more lethargic, as if exhausted. A few days later one finds near the ant a little packet of 20–30 eggs undergoing segmentation. Beside them lies a flat heap of loose white substance, only 1–2 mm. in diameter. This is the earliest rudiment of the fungus garden. Microscopical examination shows that it consists of compact masses of the well-known fungus-hyphæ, but without traces of "kohlrabi" corpuscles. As time goes on the fungus garden grows rapidly and becomes more voluminous till it reaches a diameter of about 20 cm. It seems to consist of closely aggregated spherules about 1 mm. in diameter. As soon as it has attained this size the transparent pyriform globules bud out, which Mœller called 'kohlrabi' and the ant is seen to eat them frequently, She always keeps close to the fungus garden and in it embeds her eggs. The larger of these soon become larvæ. The eggs are not spun over with fungus hyphæ but have the chorion smooth and shining. Eggs are also found in the interior of the fungus mass, which the ant keeps rearranging and redistributing from time to time. It was easy, for purposes of observation, to transfer the ant to a terrarium. Without excavating anew she remained with her garden on the fresh layer of earth. The garden did not grow, but rather diminished in volume, for it is difficult to imitate the conditions, especially the precise degree of moisture, in which it grows and develops in its cavity. I failed therefore to keep the ant and her garden till the first workers appeared. The time required to accomplish this must be between two and three months. Presumably the last phase of this first brood period is very precarious, since leaves must be brought in to serve as a substratum for the further growth of the fungus garden.

In any event, the development of the garden is in need of further elucidation. According to my investigations, which need fuller confirmation, the organic substratum is provided in the form of malaxated eggs, but perhaps the soil, which is rich in vegetable mould, may itself contain nutrient substances .... As soon as the first workers appear, the colony may be regarded as established and the opening up of the burrow, the enlarging of the first chamber, carrying in of leaves, etc., lead to the well-known conditions of the adult colony....The preceding description is hardly complete without an answer to the question: Whence come the fungus germs for the establishment of the new garden?" After searching the queen for fungus spores concealed about her person, von Ihering made the important discovery that "every *Atta* queen, on leaving the parental nest, carries in the posterior portion of her oral chamber a loose pellet, .6 mm. in diameter, consisting of hyphæ of *Rozites gongylophora*, small fragments of bleached *i. e.*, chlorophylless leaves, and chitinous bristles. The last are undoubtedly derived from the larvæ undergoing ecdysis in the parental nest." Von Ihering is of the opinion that the female keeps the pellet of hyphæ, etc., in her mouth till she has excavated her chamber and then spits it out where it will serve to kindle the fungus garden of the new colony.

The observations of Gœldi, (Forel 1905, Gœldi 1905 *a* and *b*) are little more than a confirmation of those of von Ihering. He maintains that the fungus is actually grown on some of the malaxated eggs of the *Atta* queen, who would thus be sacrificing a part of her offspring as a culture medium for the fungus that goes to nourish both herself and her workers in their larval and adult stages.

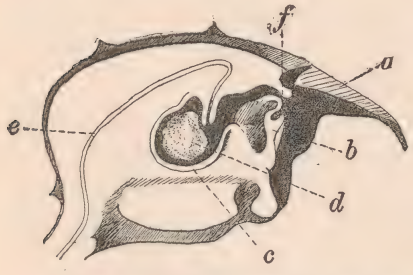

Fig. 1. Head of recently fertilized queen of *Atta sexdens* longitudinally bisected.
a. Mandible; *b*, labium retracted; *c*, buccal pocket containing *d*, the pellet of fungus hyphæ carried from the parental nest; *e*, œsophagus; *f*, oral orifice. (After J. Huber.)

None of these investigators succeeded in rearing an *Atta* colony from its very inception till the hatching of the firstling workers and the bringing in of the leaves for the purpose of keeping up the fungus culture. This has been accomplished very recently by Jakob Huber (1905) who besides correcting a few errors in the work of his predecessors, has added a number of new and important observations. His paper, from which the following abstract is taken, also contains several interesting figures from photographs of the *Atta* female, her progeny, and fungus garden. The female expels the pellet from her buccal pocket (Fig. 1, *c*) the day following the nuptial flight. It is a little mass .5 mm. in diameter, white, yellowish or even black in color, and

consists of fungus hyphæ imbedded in the substances collected from the ant's body by means of the strigils on her fore feet and thence deposited in her mouth. By the third day 6 to 10 eggs are laid (Fig. 2). At this time also the pellet begins to send out hyphæ in all directions. The female separates the pellet into two masses on this or the following day (Fig. 3). For the next 10 to 12 days she lays about 10 eggs daily, while the fungus flocculi grow larger and more numerous. At first the eggs and flocculi are kept separate, but they are soon brought together and at least a part of the eggs are placed on or among the flocculi. Eight or ten days later the flocculi have become so numerous that they form when brought together a round or elliptical disc about 1 cm. in diameter. This disc is converted into a dish-like mass with central depression in which the eggs and larvæ are thenceforth kept. The first larvæ appear about 14 to 16 days after the *Atta* female has completed her burrow, and the first pupæ appear about a month after the inception of the colony. By this time the fungus garden has a diameter of about 2 cm. There are no "kohlrabi" corpuscles in the earlier stages, and when first seen they are at the periphery of the disc. A week later the pupæ begin to turn brown and in a few days the first workers hatch. Hence the time required for the establishment of a colony under the most favorable conditions is about 40 days. After this rapid survey of the matter, Huber asks the important question: How does the *Atta* female manage to keep the fungus alive? Obviously the small amount of substance in the original pellet must soon be exhausted and the growing hyphæ must be supplied with nutriment from some other source. His interesting answer to this question may be given in his own words: "After carefully watching the ant for hours she will be seen suddenly to tear a little piece of the fungus from the garden with her mandibles and hold it against the tip of her gaster, which is bent forward for this purpose (Fig. 4). At the same time she emits from her vent a clear yellowish or brownish droplet which is at once absorbed by the tuft of hyphæ. Hereupon the tuft is again inserted, amid much feeling about with the antennæ, in the garden, but usually not in the same spot from which it was taken, and is then patted in place by means of the fore feet (Fig. 5). The fungus then sucks up the drop more or less quickly.

Fig. 2. Eggs and fungus garden in cell of queen *Atta sexdens*, forty-eight hours after the nuptial flight. (After J. Huber.)

Fig. 3. Eggs and fungus garden in cell of queen *Atta sexdens* seventy-two hours after the nuptial flight. (After J. Huber.)

Often several of these drops may be clearly seen scattered over the young fungus garden [Fig. 6]. According to my observations this performance is repeated usually once or twice an hour, and sometimes, indeed, even more frequently. It can almost always be observed a number of times in succession when a mother ant that has no fungus, as sometimes happens in the cultures, is given a piece of fungus belonging to another *Atta* female or from an older colony. The mother ant is visibly excited while she explores the gift with her antennæ, and usually in a few minutes begins to divide it up and rebuild it. At such times she first applies each piece to her vent in the manner above described and drenches it with a fecal droplet." From these observations Huber concludes that the droplet must be liquid excrement and that the fungus owes its growth to this method of manuring. A direct use of malaxated eggs for this purpose was never observed and could not be detected by microscopical examination, although a number of observations show that the same result may be accomplished indirectly, namely by the female eating her own eggs. This habit is so common and apparently so normal that Huber estimates that 9 out of every 10 eggs are devoured by the mother, often as soon as they are laid. The life of the *Atta* female in her little cell during all this time is very rhythmical. At regular intervals she conscientiously examines the walls of the cavity, flattens out the earth, etc. She devotes more time to licking and manuring the fungus garden and, of course, lavishes most care on the brood. As soon as the larvæ appear they are fed directly with eggs thrust into their mouths by their mother. Huber concludes that this is their normal diet till the first workers hatch. He never saw the female either eating the fungus mycelium herself or feeding it to the young. As proof of his contention he cites the case of one of his *Atta* queens who brought up a brood without a fungus garden. With the appearance of the firstling workers, which are minims, that is members of the smallest worker caste, a change comes over the colony. They begin to

Fig. 4. Silhouette of a queen *Atta sexdens* in the act of manuring her fungus garden. (From an instantaneous photograph after J. Huber.)

Fig. 5. Silhouette of a queen *Atta sexdens* replacing in the fungus garden tuft of mycelium saturated with fecal liquid. (From an instantaneous photograph after J. Huber.)

usurp the functions of the mother ant. They manure the garden, which at the time of their appearance measures hardly more than 2.5 cm. in diameter, and feed the larvæ with their mothers' eggs. The workers themselves, however, feed on the "kohlrabi" which has been developing on the hyphæ in the meantime. After about a week some of the workers begin to dig in the earth, and ten days after the appearance of the first worker and seven weeks after the inception of the colony, they break through to the surface of the soil and surround the entrance of the nest with a tiny crater of earthen pellets. They now begin to bring in pieces of leaves, knead them up into minute wads, and insert them in the fungus garden. The method of man-

Fig. 6. Fungus garden of *Atta sexdens* fourteen days after the nuptial flight. There are about 100 eggs which the queen has placed in a depression in the middle of the garden. Near the periphery there are three drops of the fecal liquid with which the queen manures her garden. (After J. Huber.)

uring the garden with fecal droplets seems now to be abandoned. The mother *Atta* henceforth pays no attention to the development of the garden or to the brood, but degenerates into a sluggish egg-laying machine, while the multifarious labors of the colony devolve on the workers. In the meantime the "kohlrabi" has become so abundant that it can be fed to the larvæ. In concluding his paper Huber makes the important observation that fertile females of *Atta sexdens* are readily adopted by strange workers of their own species. Such adoptions may be frequently resorted to in a state of nature and would perhaps account for the enormous size and great age of some of the formicaries of the larger species of *Atta*, which in this respect resemble the colonies of *Formica rufa* and *F. exsectoides* in the north temperate zone.

Part II. Descriptions of North American Attii.

1. **Atta texana** *Buckley.*

Myrmica (*Atta*) *texana* Buckley, Proc. Acad. Nat. Sci. Phila., 1860, p. 233, ☿ ♀ ♂.
Myrmica texana Buckley, Proc. Acad. Nat. Sci. Phila., 1861, pp. 9–10.
Œcodoma texana Lincecum, Proc. Acad. Nat. Sci. Phila., 1867, pp. 24–31.
Œcodoma texana Buckley, Proc. Ent. Soc. Phila., VI, 1867, p. 347, no. 62, ☿ ♀ ♂.
Atta fervens Townsend, Amer. Entom. and Botan., II, 1870, pp. 324–325, figs. 202 and 203, ☿ ♀.
Atta fervens McCook, Ann. Mag. Nat. Hist., (5) III, 1879, pp. 442–449.
Atta fervens McCook, Nature, XX, 1879, p. 583.
Atta fervens McCook, Proc. Acad. Nat. Sci. Phila., 1879, pp. 33–40.
Œcodoma texana Nehrling, Zool. Garten, XXV, 1884, p. 265.
Atta fervens Dalla Torre, Catalog. Hymen., VII, 1893, pp. 152, 153 (in part).
Atta fervens Emery, Zool. Jahrb., Abth. f. Syst., VIII, 1894, p. 329.
Atta fervens Forel, Biol. Centr. Amer., Hymen., III, 1899-1900, p. 33 (in part).
Atta fervens Wheeler, Amer. Natur., XXXV, 1900, pp. 851–862, 2 figs.
Atta fervens Wheeler, Trans. Texas Acad. Sci., IV, no. 2, 1902, p. 13.

Soldier. (Fig. 7 and Pl. XLIX, Fig. 11.) Length 10–12 mm.

Head cordate: without the mandibles broader than long, with rounded posterior corners and shallow obtuse occipital excision. Mandibles long, flattened, with a large acute apical and 9 or 10 blunt, subequal basal teeth. Clypeus short and broad, with bidentate and arcuately excised anterior border. Frontal carinæ continued as distinct, diverging ridges as far back as the middle of the head; their lobes with a prominent tooth above the insertion of each antennal scape. Frontal area large, triangular, indistinct. Antennæ slender. Eyes convex, hemispherical, about $\frac{1}{4}$ the distance from the anterior to the posterior corners of the head. Ocelli absent. There is a tooth on the lateral carina between the eye and the clypeus, two small spines or teeth on the ventrolateral surface of the head, one or two similar teeth on each occipital lobe and behind them a large prominent spine. Thorax with four pairs of spines: one small acute pair on the inferior corners of the pronotum, a large robust, acute and erect pair, sometimes reduced to conical projections, above on the sides of the pronotum; a much shorter, often more slender and less tapering pair on the mesonotum, and a long, acute, backwardly directed pair on the epinotum. The last are prolonged forward at their bases in the form of a pair of anteriorly converging ridges. Petiole about $1\frac{1}{2}$ times as long as broad, pentagonal from above, broadest in the middle; node concave in the middle with a ridge on each side. Postpetiole nearly twice as broad as the petiole, about as broad as long, narrowed in front, flattened above, with a pair of more pronounced and uneven mesial and a pair of shorter and feebler lateral ridges. Gaster oval, broadest at the middle, with somewhat angular anterior corners and abruptly conical tip. Legs very long and slender.

Mandibles and clypeus shining; the former coarsely striatopunctate, the latter finely and unevenly punctate. Remainder of body opaque, very finely punctate or granular.

Hairs long, erect or reclinate, curved, golden yellow or fulvous, covering the

body and appendages. Pubescence abundant on the body and rather long, of the same color as the hairs; absent on the appendages, with the exception of the antennal funiculi.

Ferruginous brown; borders of mandibles black.

Media. (Fig. 7 and Pl. XLIX, Fig. 13). Length: 3–9 mm.

Resembling the soldier but with proportionally smaller head and all the cephalic and thoracic spines longer and more acute, especially the posterior occipital and the superior pronotal pairs. The latter are often much longer than the epinotal spines and curved forward at their tips.

Minima. (Fig. 7 and Pl. XLIX, Fig. 14.) Length: 1.5–2.5 mm.

Head proportionally smaller than in the soldier and media; mandibular teeth more acute; lobes of frontal carinæ, lateral carinæ and ventro-lateral surfaces of head without teeth. Anterior and posterior occipital spines much reduced. On the thorax the superior are not longer than the inferior pronotal spines and much shorter than those on the epinotum. Pubescence and hairs much sparser and more inconspicuous than in the soldier and media.

Female. (Fig. 7.) Length: 17–18 mm.

Head without the mandibles, much broader than long, arcuately excised behind, with rather straight, anteriorly converging sides. Mandibles and clypeus similar to those of the soldier, but the former with at least 12 basal teeth, the latter with the two teeth of its anterior border blunter and more prominent. Frontal and lateral carinæ with prominent teeth. Spines of anterior occipital and ventro-lateral surface of head reduced to low projections. Posterior occipital spines small but acute. Thorax robust, distinctly longer than the first gastric segment; twice as broad as the head. Inferior pronotal spines small and acute; superior pair lacking. Scutellum rounded, convex, without a median longitudinal impression. Epinotum with a pair of small, acute, backwardly directed spines, each of which has a prominent, elongate swelling in front of its base. Petiole more than twice as broad as long; broadest in the middle and produced on each side into a long, slender spine or process. Postpetiole less than twice as broad as the petiole and fully twice as broad as long, widest behind with two pairs of truncated lateral projections, of which the posterior is the longer. Lower surface with a prominent transverse ridge. Gaster nearly as broad as long, but little broader in the middle than at its straight anterior border. Anterior corners of first segment rectangular. Legs slender and weak.

Mandibles, anterior border of clypeus, scapes and legs shining; clypeus and mandibles punctate, the latter also very coarsely striated. Remainder of body opaque, granular-rugulose. Mesopleuræ coarsely rugose.

Hairs and pubescence tawny, the former dense and erect on the body and appendages, the latter sparse, somewhat reclinate and hooked, most conspicuous on the head and gaster.

Deep maroon brown, legs more reddish; borders of mandibles black. Wings with ferruginous brown veins and a strong suffusion of the same color in the membranes, especially along their anterior borders.

Male. (Fig. 7, and Pl. XLIX, Fig. 24.) Length: 13–14 mm.

Head small, without the mandibles but little broader than long, flattened behind but not excised, with large and very prominent eyes and ocelli. Mandibles well-

developed, with pointed tips and about a dozen blunt basal teeth. Anterior border of clypeus with two broad blunt teeth and a median excision. Space between frontal and lateral carinæ concave, elliptical. Antennæ slender. Cephalic spines obsolete, except those of the posterior occipital region, which are short, acute and sometimes bent downwards at their tips. Thorax through the wing insertions more than twice as broad as the head. Mesonotum as broad as long, projecting in front over the small pronotum, which has a short, broad tooth at its inferior corner on each side. Scutellum convex, with a faint longitudinal impression in the middle. Epinotum unarmed. Petiole and postpetiole similar to those of the female, but each side of the former sometimes with two spines of unequal length, and the postpetiole is less angular on the sides. Gaster as broad as long, elliptical, convex above and below. Hypopygium broader than long, fenestrate, with its free edge faintly bidentate and not excised but instead slightly produced in the middle. Outer genital appendages slender, strap-shaped with subparallel borders and obliquely truncated tips. Median pair long with infolded edges and geniculate towards the apex, which is flattened and provided with a strong basal and two feebler terminal teeth. Wings 22 mm. long.

Mandibles somewhat shining, finely striate and coarsely punctate. Head and thorax opaque, pedicel and gaster slightly shining. Clypeus, frontal area and facial concavities uniformly granular, remainder of head coarsely reticulate-rugose. Thorax rather coarsely granular and punctate. Mesonotum with undulating transverse rugulæ. Pedicel and gaster densely and finely punctate, with more scattered, larger piligerous punctures. Legs and genitalia shining.

Hairs fulvous brown, long, dense, and erect on the head and upper portions of thorax and pedicel, sparser on the pleuræ and legs; on the gaster much shorter and sparser and hardly more than a dilute, suberect pubescence. Outer genital valves and free edge of hypopygium with numerous hairs.

Ferruginous brown; gaster, genitalia, legs and antennæ somewhat paler. Wings like those of the female.

Texas: Chapel Hill, Brenham, La Grange, Ye Gua Creek (Lincecum); Austin (Buckley, Lincecum, Townsend, McCook, Wheeler); Alice, New Braunfels, Elgin, Granite Mountain (Wheeler).

There exists some confusion in the literature in regard to this species. The European myrmecologists, Mayr, Forel and Emery, have confounded it with a closely related, but in my opinion, perfectly distinct Mexican species, *A. mexicana* F. Smith (*A. fervens* Say). The soldiers and mediæ of the latter, of which I possess specimens from Guadalajara (J. F. McClendon), Irapuato (C. H. T. Townsend), Esquinapa (J. H. Batty), Cuernavaca and Queretaro (Wheeler), differ from the corresponding phases of *texana* in having the head smooth, shining and hairless above. In the male the hypopygium (Pl. L, Fig. 25) is shorter, distinctly excised in the middle with the blunt teeth further apart, and without a median fenestra. The outer genital appendages are slender and taper to a sharp point; the middle pair are more slender and flattened, less geniculate and more uniformly curved. In Pl. L, Figs. 21–25 are given camera drawings of the male hypopygia of all the species of *Atta* s. str. except *columbica* (which is probably

a variety of *cephalotes*), because, as Mayr has shown in his work on the Formicidæ of the Novara Expedition, this scelerite and the genital appendages furnish excellent characters for distinguishing the species.

2. **Atta mexicana** (*F. Smith*).

The name of this species, which is not known to occur in Texas, though it is widely distributed in Mexico at an altitude of 5,000 to 7,000 feet, must either be attributed to Drury, and not, as has usually been done, to Say, or if, as Dalla Torre maintains, the *Formica fervens* of Drury is merely a synonym of *A. cephalotes*, we must adopt *A. mexicana* F. Smith as the name of the Mexican form. As it seems to me to be impossible to determine the species to which Drury's female specimen belonged, I believe that the name *mexicana* should be adopted. The synonymy disentangled from that of *A. texana* would then read as follows:

? *Formica fervens* Drury, Illustr. Nat. Hist., III, 1782, p. 58, pl. 42, fig. 3. ♀.
Atta fervens Say, Boston Journ. Nat. Hist., I, 3, 1836, p. 290, ♀.
Œcodoma mexicana F. Smith, Catalog. Hymen. Brit. Mus., VI, 1858, p. 185, no. 9 ♀. Pl. X, fig. 20.
Œcodoma Mexicana Norton, Amer. Natur., II, 1868, p. 66, pl. I, figs. 9 and 10. ☿ ♀.
Œcodoma mexicana Norton, Proc. Essex Inst., VI, 1868, Comm. p. 9, fig. ☿ ♀.
? *Œcodoma mexicana* Moreno, Naturaleza, III, 1876, pp. 189–190.
Atta fervens Leconte, Writings of Th. Say., Entom., II, 1859, p. 734.
Atta fervens Mayr, Reise der Novara, II, 1. Formicidæ, 1865, p. 81, ☿ ♀ ♂.
Atta fervens Forel, Bull. Soc. Vaud. Sc. Nat., XX, 1884, p. 47 (in part).
Atta fervens Dalla Torre, Catalog. Hymen., VII, 1893, pp. 152, 153 (in part).
Atta lævigata Pergande, Proc. Calif. Acad. Nat. Sci. (2), V, 1895, p. 896, ☿.
Atta fervens Forel, Biol. Centr.-Am., Hymen., III, 1899–1900, p. 33 (in part).
Atta fervens Forel, Ann. Soc. Ent. Belg., XLV, 1901, p. 124, ☿.
Atta fervens Wheeler, Ann. Soc. Ent. Belg., XLV, 1901, p. 200, ☿.

3. **Atta (Mœllerius) versicolor** *Pergande.*

Atta versicolor Pergande, Proc. Calif. Acad. Sci. (2), IV, 1893, pp. 31, 32, ☿.
Atta (Acromyrmex) versicolor Emery, Zool. Jahrb., Abth. f. Syst., VIII, 1894, p. 330, ☿.
Atta versicolor Fenner, Entom. News, VI, 1895, p. 215.
Atta (Acromyrmex) versicolor Forel, Biol. Centr.-Am., Hymen., III, 1899–1900, p. 36, ☿.
Atta (Mœllerius) versicolor Emery. R. Accad. Sci. Ist. Bologna, April 1905, pp. 108, 111, ☿.

Worker, (Pl. XLIX, Fig. 5.) Length: 2.3–6 mm.
Head without the mandibles broader than long, in larger specimens somewhat

narrowed in front, broadly and obtusely excised behind, with rounded posterior corners and slightly convex sides. Eyes convex, less than $\frac{1}{3}$ the distance from the anterior to the posterior corners. Mandibles rather convex, with several blunt teeth. Clypeus concave in the middle, with two very short, blunt teeth on the anterior margin. Frontal carinæ with expanded, toothed lobes in front. Frontal area obsolete. Antennal scapes reaching to the posterior corners of the head, somewhat incrassated towards their tips. Lateral carinæ with a short, acute tooth. Postocular spines absent; anterior and superior occipital regions with a number of short teeth or spines; posterior occipital region with a longer acute spine on each side. Pronotum with a pair of short, downwardly directed inferior and a pair of long, robust and acute superior spines directed forward and outward. Mesonotum with two pairs of spines, the anterior about half as long as the superior pronotal pair, but more rapidly tapering and directed upward and backward; the posterior pair smaller and closer together. Epinotum with two spines which are nearly as long as the superior pronotal pair but more slender and directed backward, upward and slightly outward. Petiole longer than broad, its node subrectangular, with four equidistant, subequal teeth in a transverse row. Postpetiole nearly twice as broad as the petiole, broader than long, concave above, with six short bidentate spines, four in a transverse anterior row and two behind and more widely separated at their bases. Gaster broadly elliptical, broadest behind the middle; basal segment with a median longitudinal depression, on each side of which there are several acute tubercles, longest near the anterior and lateral margins.

Mandibles shining, coarsely punctate and striate; remainder of body, including the legs and scapes, opaque, densely punctate. Head, thorax, pedicel and anterior border of gaster vermiculately or reticulately rugulose. Basal gastric segment with scattered, shallow foveolæ.

Hairs brown or tawny, suberect, not very abundant, rather short, curved or hooked on the body, straighter on the scapes and legs.

Ferruginous brown; borders of mandibles and anterior border of clypeus black.

Female. Length: 8 mm.

Head resembling that of the worker, but the posterior corners are more acute and the antennal scapes are longer. Pronotum with two broad and rather blunt inferior and two acute superior spines, which are directed forward and outward. Scutellum trapezoidal with bidentate posterior edge. Epinotal spines long, curved and diverging, of nearly uniform thickness up to their rapidly tapering tips which are bent downwards. Petiole and postpetiole similar to those of the worker, but the median pair of teeth in the former longer than the lateral pair and the spines on the postpetiole reduced to small teeth. Gaster pyriform, with the first segment flattened above and without the pointed tubercles.

Mandibles and legs shining; remainder of body opaque. Head coarsely, densely and crenately rugose, the rugæ being longitudinal on the sides but diverging from the front and median line on the upper surface. Thorax covered with rugæ similar to those on the head, transverse on the pronotum, longitudinal on the mesonotum and pleuræ, and irregular on the scutellum. Pedicel and gaster densely and irregularly rugulose; on the middle of the first segment of the latter the rugulæ are more regular and longitudinal. Antennal scapes and legs coarsely punctate and more or less roughened.

Pilosity like that of the worker.

Ferruginous brown; upper surface of head, mesonotum and gaster blackish, the mesonotum with a V-shaped red spot on the middle and the gaster with a pair of elliptical ferruginous spots on the basal segment. Wings opaque yellowish brown, with dull yellow veins.

Male. (Pl. L, Fig. 26.) Length: 8 mm.

Head, without the mandibles and eyes, as long as broad, subrectangular, with nearly straight posterior border. Eyes large, protruding, hemispherical, with their posterior orbits at the middle of the head. Mandibles well-developed, acute, flattened and multidentate. Clypeus very faintly and sinuately excised in the middle. Frontal and lateral carinæ without teeth. Antennal scapes extending fully $\frac{1}{3}$ their length beyond the posterior corners of the head. The latter with a small, acute superior and a broad flattened inferior tooth on each side. Pronotum with a larger inferior and much smaller superior tooth on each side. Mesonotum with distinct Mayrian furrows. Scutellum with a median longitudinal depression and a pair of blunt posterior teeth. Epinotum with short, convex base and longer straight declivity; spines like those of the female but more slender and tapering more gradually. Petiole and postpetiole like those of the female, the former with small acute teeth above and three lateral teeth, the latter with four teeth on each side. Gaster broadly elliptical, with the basal segment flattened above and without tubercles. Genital appendages convex, curved inward, with broad, rounded, subtruncate tips. Legs slender.

Body including the mandibles and legs, opaque; gaster slightly shining. Mandibles finely striated and coarsely punctate. Head, thorax and pedicel densely rugulose, the rugulæ being longitudinal on the head, mesonotum, scutellum, pleuræ and epinotum, and transverse on the pronotum, petiole and postpetiole. Gaster and legs densely punctate. Genital appendages with a few scattered foveolæ.

Pilosity like that of the worker and female.

Black; mandibles, border of clypeus, frontal carinæ, neck, antennæ, coxæ, tibiæ, tarsi and gaster ferruginous brown, posterior borders of gastric segments and genitalia somewhat paler. Wings like those of the female.

Arizona: Tucson (Fenner, Wheeler); Yucca (Wheeler).

Mexico: Calamujuet, Lower California (Eisen and Haines); Sonora (Coll. Am. Mus. Nat. Hist.).

The types are from Calamujuet; the above description is drawn from Tucson specimens.

4. **Atta (Mœllerius) versicolor chisosensis** subsp. nov.

A number of workers taken by Judge O. W. Williams in the Chisos Mountains of southwestern Texas, and a few workers taken by myself at Terlingua in the same region, represent a distinct subspecies.

They differ from the typical *versicolor* in their distinctly lighter and more yellowish color, much less pronounced sculpture and in having only a few (about 12) pointed tubercles on each side of the median gastric depression,

whereas in the typical form there are two or three times as many. Owing to their feebler sculpture the workers of *chisosensis* are throughout much more shining than the typical form.

5. Atta (Trachymyrmex) septentrionalis *McCook.*

? *Œcodoma virginiana* Buckley, Proc. Ent. Soc. Phila., VI, 1867, p. 346, no. 61, ☿.
? *Œcodoma tardigrada* Buckley, Proc. Ent. Soc. Phila., VI, 1867, p. 349, no. 65, ☿. ♀ ♂.
Atta septentrionalis McCook, Proc. Acad. Nat. Sci. Phila., 1880, pp. 359–363, Fig. ☿.
Atta (*Acromyrmex*) *tardigrada* Forel, Bull. Soc. Vaud. Sci. Nat. (2) XX, p. 91, 1884, p. 358, ☿ ♀ ♂.
Atta tardigrada Mayr, Verh. zool. bot. Ges. Wien, XXXVI, 1886, p. 442.
Atta (*Trachymyrmex*) *tardigrada* Forel, Ann. Soc. Ent. Belg., XXXVII, 1893, p. 601.
Atta tardigrada Dalla Torre, Catalog. Hymen., VII, 1893, p. 154.
Atta tardigrada var. *septentrionalis*, Catalog. Hymen., VII, 1893, p. 154.
Atta (*Trachymyrmex*) *tardigrada* Emery, Zool. Jahrb., Abth. f. Syst., VIII, 1894, p. 329.
Atta (*Trachymyrmex*) *tardigrada* Forel, Rivista Sci. Biol., II, 1900, p. 9.
Atta (*Trachymyrmex*) *tardigrada* Forel, Ann. Soc. Ent. Belg., XLV, pp. 396, 397.
Atta (*Trachymyrmex*) *septentrionalis* Wheeler, Trans. Tex. Acad. Sci., IV, Pt. II, no. 2, 1902, pp. 13, 14.
Atta (*Trachymyrmex*) *septentrionalis* Wheeler, Psyche, June, 1903, p. 101, Fig. 6b.
Atta (*Trachymyrmex*) *septentrionalis* Wheeler, Bull. Am. Mus. Nat. Hist., XXI, 1905, pp. 386, 387.

Worker. (Pl. XLIX, Fig. 4.) Length: 2.5–3 mm.

Head, without the mandibles, about as broad as long, a little broader behind than in front, with obtusely excised posterior border, somewhat rounded posterior angles and rather straight sides. Eyes not very prominent, more than $\frac{1}{3}$ the distance from the anterior to the posterior corners of the head. Mandibles with two larger acute apical and 7 or 8 small basal teeth. Anterior border of clypeus sinuately excised in the middle. Frontal area triangular, obsolescent. Frontal carinæ with flattened, rounded lobes in front, continued back as a pair of diverging ridges beyond the middle of the head as far as but not meeting the lateral carinæ. Antennal scapes extending about $\frac{1}{4}$ their length beyond the posterior corners of the head, somewhat thickened towards their tips. Region between the frontal carinæ and posterior corners of the head covered with small acute tubercles, one pair of which on the posterior corners is longer and bidentate. Pronotum with a pair of blunt, downwardly directed inferior spines, two long acute superior spines and between these in the middle a pair of short bidentate spines or tubercles, which are closer to each other than to the lateral tubercles. Mesonotum with two pairs of blunt spines. Mesoëpinotal constriction pronounced. Epinotum with four longitudinal rows of tubercles, the inner continued back into the bases of a pair of acute spines which are directed upward, backward and outward and are from $\frac{1}{3}$ to $\frac{1}{2}$ as long as the slightly convex base of the epinotum. Declivity sloping, forming in profile an ob-

tuse angle with the base. The upper surface of the thorax and all the spines, with the exception of the inferior pronotal pair are covered with small tubercles. Petiolar node from above nearly square, a little broader than long; in profile its anterior surface is flattened, its summit acute and furnished with a pair of teeth. On each side of these there is also a small blunt tooth. Postpetiole about as broad as the epinotum, somewhat more than twice as broad as the petiole, and distinctly broader than long, subpentagonal from above, concave in the middle behind and covered with small tubercles. Gaster pyriform, broadest behind the middle; first segment with a faint, longitudinal, median depression and a short ridge on each lateral border. The dorsal surface is covered rather uniformly with small, acute tubercles, as are also the antennal scapes.

Mandibles and anterior border of clypeus faintly shining or glossy, the former finely and densely striated. Remainder of body and appendages opaque and indistinctly granular.

Hairs brownish yellow, short, hooked, more or less erect and not very abundant, usually arising from the small tubercles and covering the body and appendages rather uniformly.

Body ferruginous brown, legs slightly paler, mandibular teeth black, front and vertex dark brown; gaster in many specimens with a broad longitudinal fuscous or blackish stripe on the middle of the first segment.

Female. Length: 3.8–4 mm.

Head resembling that of the worker. Pronotum besides the blunt, downwardly directed inferior spines, with a pair of strong, somewhat flattened, acute superior spines directed outward and somewhat forward. Scutellum semicircularly excised and bidentate behind. Epinotal spines long, of rather uniform thickness to within a short distance of their acute, rapidly tapering tips. Pedicel and gaster as in the worker, but the lateral teeth of the petiole are smaller and blunter and the posterior margin of the postpetiole is excised. Wings 4 mm. long.

Sculpture similar to that of the worker; mesonotum and scutellum covered with rows of small elongated tubercles.

Like the worker also in pilosity and coloration. Head with a large black spot on the ocellar region and the gastric stripe is deeper and more distinct, but not reaching the anterior border of the basal segment. Wings blackish with veins of the same color; costal cell yellowish.

Male. Length: 3–3.5 mm.

Head but little broader behind than in front, broadest in the region of the eyes, with slightly convex posterior border. Eyes convex, posterior orbits at the middle of the head. Mandibles like those of the worker but smaller. Clypeus with broad, entire anterior margin. Frontal carinæ lobed in front, uniting behind with the lateral carinæ, which are furnished with a small tooth in the middle. Posterior corners of head with several small, acute spines or teeth. Antennæ slender; scapes somewhat thickened distally and surpassing the posterior corners by about $\frac{1}{3}$ of their length. Pronotum with small acute superior and inferior teeth. Mesonotum with well-developed Mayrian furrows. Scutellum similar to that of the female. Epinotum with subequal base and declivity; spines slender, acute, diverging, bent downward at their tips, their bases continued forward as a pair of crenated ridges on to the base of the epinotum. Petiole and postpetiole like those of the worker, but the

latter segment without distinct tubercles. Gaster elliptical, convex above, the first segment with smaller and more scattered tubercles than in the worker and female, and without a median longitudinal impression. Outer genital appendages broad and short, with rounded edges; median pair with straight, slender, pointed tips. Hypopygium entire, with a broad, rounded point in the middle. Legs long and slender; terminal tarsal joint not enlarged.

Opaque, mandibles and clypeus granular; head and thoracic dorsum coarsely, pleuræ, petiole and postpetiole more finely reticulate-rugose. Epinotum and gaster finely reticulate or granular. Legs smoother and somewhat shining.

Pilosity similar to that of the worker and female.

Ferruginous brown; upper surface of head, thorax, pedicel and first gastric segment more or less blackened; legs and posterior borders of gastric segments yellowish; antennal scapes dark brown. Wings as in the female.

Texas: Austin, Montopolis, Milano (Wheeler); Denton (W. H. Long); Paris (Miss A. Rucker, C. T. Brues).

Florida: (Mrs. Mary Treat, T. Pergande), Miami and Jacksonville (Wheeler).

District of Columbia: Washington (Pergande, Swingle).

North Carolina: Black Mountain (Forel).

New Jersey: Vineland (Mrs. Treat); Toms River (Morris, McCook); Lakehurst (Wheeler, W. T. Davis); Lucaston (E. Daecke); Miltown and Manusquam (Davis).

I believe that Buckley's name *tardigrada,* which has been very generally applied to this species, should be rejected and replaced by McCook's *septentrionalis,* first, because Buckley's description will apply equally well to this or the following species or even to *Mycetosoritis hartmanni,* although his account of the nests applies to none of these but rather to a small colony of *Atta texana;* and second, although Forel wrote in 1884 that Mayr had in his possession a type specimen of Buckley's *tardigrada* which made it possible to refer Florida specimens received from Mrs. Treat to this species, Dr. Mayr writes me (March 24, 1902); "Ich besitze von *Atta* (*Trachymyrmex*) *tardigrada* keinen Buckley'schen Typus." There is no possible means of ascertaining just what species Buckley described. McCook's description is equally worthless, but his specimens were redescribed by Forel, so that the name *septentrionalis* must stand. The above description is drawn from specimens taken early in May from a single colony at Montopolis, near Austin, Texas. Forel regarded McCook's specimens as representing a variety of the southern form, but Emery failed to distinguish any varietal differences between southern and northern specimens. A number of workers taken by me at Lakehurst, New Jersey are larger (3.4–3.6 mm.) than specimens from Texas and Florida and are of a paler, more yellowish color with a darker and more distinct gastric stripe. A deälated female from Lake-

hurst and a winged individual from Lucaston, New Jersey agree in having a dark spot on the middle of the pronotum, one on the postpetiole and in having the infuscation of the head and middle of the gaster more extensive. If we regard the New Jersey specimens as representing the typical form of the species it will be necessary to distinguish the darker southern form as a variety, for which I would suggest the name *obscurior* var. nov.

6. **Atta (Trachymyrmex) turrifex** *Wheeler.*

Wheeler, Psyche, June, 1903, pp. 100–102, fig. 6a, ☿ ♀.

Worker. (Pl. XLIX, Fig. 3.) Length: 3–3.75 mm.

Head without the mandibles a little longer than broad, slightly broader behind than in front, with obtusely excised posterior border, rather straight sides and prominent posterior angles. Eyes convex, in front of the middle of the head. Mandibles pointed, 7–8-toothed. Clypeus sinuately and rather deeply excised in the middle. Frontal area triangular, indistinct. Frontal carinæ with large round anterior lobes, somewhat concave in the middle, and continued back as a pair of diverging ridges nearly as far as the posterior corners of the head, but not meeting the almost equally long lateral carinæ. Antennæ robust; scapes reaching only to the posterior corners and fitting into deep grooves between the frontal and lateral carinæ. Upper surface of head, with the exception of these grooves, covered with tubercles, two pairs of which on the superior and inferior portions of the occipital corners are larger than the others and bidentate. Scapes covered with similar but smaller tubercles. Pronotum on each side with an acute downwardly directed inferior spine; above with a pair of rather long, acute lateral spines and a shorter bifurcated median spine. Mesonotum with two pairs of thick blunt spines. Mesoëpinotal constriction very pronounced. Epinotum with subequal base and declivity at right angles to each other in profile; the former convex, the latter concave; spines acute, nearly as long as the base, directed upward, backward and outward and prolonged forward at their bases as a pair of subparallel, crenated ridges lying between a shorter pair of similar lateral ridges. All the thoracic spines, with the exception of the inferior pronotal pair, are covered with small tubercles. Similar tubercles are also scattered over the dorsal surface of the thorax between the spines. Petiole from above as broad as long, nearly square, with a transverse row of four equidistant tubercles across its middle and connected with the median pair by longitudinal ridges. There is another pair near the posterior edge of the segment. Postpetiole twice as broad as the petiole and nearly twice as broad as long, impressed in the middle behind and covered with small tubercles. Gaster suboblong, with straight anterior border and subparallel sides, a little broader behind than in front, convex above and below; first segment with longitudinal ridges half way down its sides, a faint median and two lateral depressions. Its whole surface is covered with small tubercles which are connected with one another by a net-work of indistinct ridges. Legs stout, and as far as the second tarsal joint, covered with tubercles which are somewhat smaller than those on the body.

Mandibles with shining, coarsely striatopunctate tips, and opaque, finely striated bases. Remainder of body opaque, obscurely granular and more or less rugulose.

Hairs brown, hooked, suberect, covering the body and appendages, except the antennal funiculi which are clothed with a very fine whitish pubescence.

Ferruginous brown; front and vertex dark brown, legs somewhat paler than the body. In old specimens the body is darker in color and the roughened portions are overlaid with a bluish bloom.

Female. Length: 4–4.5 mm.

Head resembling that of the worker. Pronotum with short, acute inferior and superior spines, the latter not flattened. Scutellum with two long, blunt teeth and a deep median excision in its posterior border. Base of epinotum barely half as long as the declivity, which is concave; spines long, stout and rather blunt. Pedicel and gaster similar to those of the worker; posterior border of the postpetiole entire. Wings 6 mm. long.

Sculpture similar to that of the worker. Mesonotum and scutellum with indistinct longitudinal rows of small tubercles; remainder of thorax granular, with minute, scattered tubercles.

Pilosity and color like those of the worker. Wings opaque brown, with darker veins.

Texas: Austin, Montopolis, Marble Falls, Fort Stockton, Paisano Pass, Marfa, Del Rio, Langtry (Wheeler).

The worker of this species may be readily distinguished from that of *septentrionalis* by the more pointed posterior corners of the head, the much shorter antennal scapes which do not extend beyond the posterior corners, the unpaired pronotal spine, and the rougher legs and gaster. The female *turrifex* is distinguished by several of these characters and also by the much longer and paler wings.

7. **Atta** (**Trachymyrmex**) **arizonensis** sp. nov.

Female (deälated). (Pl. XLIX, Figs. 9 and 10.) Length: 4.75 mm.

Head, without the mandibles, as broad as long, somewhat broader behind than in front, with straight sides, obtusely excised posterior margin and rather pointed posterior corners. Eyes moderately convex, in front of the middle of the sides. Mandibles with two larger apical and several smaller basal teeth. Anterior border of clypeus sinuately notched in the middle. Frontal area triangular, indistinct. Frontal carinæ with large reflected and rather angular lobes, without rounded impressions in their surfaces, continued back as diverging ridges nearly to the posterior corners of the head, but not meeting the much shorter lateral carinæ. Antennal scapes distally enlarged, extending about $\frac{1}{4}$ their length beyond the posterior corners of the head. The latter with numerous conical tubercles, two of which on the inferior occipital angles are somewhat larger than the others and double. Pronotum with two small, flat, lappet-like inferior spines and a pair of long, but not compressed superior spines, directed outward and slightly forward. Posterior border of scutellum with a broad median excision and a pair of blunt teeth. Base of epinotum sloping, about half as long as the concave declivity. Spines short, acute, a little longer than broad at the base, directed backward and outward. All the spines of

the thorax, excepting the inferior pronotal pair, covered with tubercles. Petiole from above oblong, slightly longer than broad, with bidentate anterior angles, and a pair of longitudinal dorsal ridges elevated into short spines or teeth at their anterior ends. Postpetiole more than twice as broad as the petiole, somewhat broader than long, transversely elliptical, with the sides produced in the middle in the form of short double spines; posterior margin semicircularly excised and somewhat reflected; upper surface with a pair of irregular elevations and numerous small tubercles. Gaster subspherical, but little longer than broad, anterior border straight, first segment obtusely ridged on the sides anteriorly, without a median depression and uniformly covered with small tubercles which are somewhat larger on the dorsal than on the ventral side. Legs well-developed and, like the antennal scapes, covered with small tubercles.

Mandibles somewhat shining, finely striated at their bases, more coarsely towards the inner edges of the blades. Remainder of body opaque, granulate-rugulose; rugulæ on the sides of the head and between the lateral and frontal carinæ longitudinal and minutely and irregularly tuberculate, on the front converging from each side towards the median line. On the thorax the rugulæ are irregularly longitudinal, more regularly on the mesonotum and scutellum where they are interrupted by low tubercles. Postpetiole and first gastric segment, especially at its base, obscurely and longitudinally rugulose.

Hairs dark brown, short, hooked or curved, suberect, uniformly covering the body and appendages. Antennal funiculi with very fine whitish pubescence.

Ferruginous brown, front and vertex darker, mandibular teeth black. Whole surface of body bluish pruinose.

Male. Length: 4.5 mm.

Head, without the eyes, somewhat longer than broad, a little broader behind than in front, with straight posterior border. Posterior orbits at the middle of the head. Mandibles well-developed, with two larger, acute apical and several small basal teeth. Clypeus with entire, broadly rounded anterior border. Frontal carinæ with well-developed anterior lobes and short posterior ridges which bend around laterally and pass over into the lateral carinæ, thus enclosing two elliptical facial cavities. Antennæ slender, scapes slightly thickened distally and reaching more than $\frac{1}{3}$ their length beyond the posterior corners of the head. Posterior corners with short, acute spines, those on the superior and inferior angles being somewhat larger than the others. Inferior and superior pronotal spines very small and acute. Mayrian furrows of mesonotum distinct but shallow. Scutellum like that of the female. Epinotum with base somewhat shorter than the oblique declivity; spines rather short, somewhat longer than broad at the base, as long as the base of the epinotum, acute, directed backward and slightly outward, covered with small tubercles. Petiole similar to that of the female but concave in the middle and traversed by four longitudinal tuberculate ridges. Postpetiole less than twice as broad as the petiole, and nearly twice as broad as long, subpentagonal, with broadly excised posterior border and covered with tubercles. Gaster elliptical, convex above, covered uniformly with small acute tubercles except in the middle line near the base. Outer genital valves short and broad, with rounded tips; median pair terminating in a straight, attenuate point. Hypopygium entire, very bluntly pointed in the middle. Legs long and slender, covered with very small and rather indistinct tubercles. Last tarsal joints enlarged.

Mandibles subopaque, very finely and indistinctly striated. Body and appendages opaque. Facial cavities granular; dorsal portions of head, mesonotum, paraptera and scutellum coarsely and reticulately rugose. Remainder of body coarsely granular, the pronotum, pleuræ and epinotum also more or less irregularly rugulose.

Hairs fulvous, similar to those of the female.

Black or dark brown; mandibles, clypeus, anterior corners of head, funiculi, thoracic sutures, tarsi, knees and tips of tibiæ, genitalia and posterior and lateral borders of the gastric segments fulvous. Wings blackish, with yellowish costal cell and brown veins.

Arizona: Palmerlee, Cochise County, Aug. 24 (C. Schaeffer).

Described from a single female and six males.

This species is clearly distinct though in certain respects it is intermediate between *T. septentrionalis* and *turrifex*. The female differs from that of *turrifex* in the longer antennal scapes, which surpass the posterior corners of the head, and the posteriorly excised postpetiole, and from both this and *septentrionalis* in its much heavier sculpture, the greater size of the pronotal spines and the shape of the gaster, which is not oblong and impressed in the middle.

8. **Atta (Trachymyrmex) jamaicensis** *Ern. André.*

Atta (Acromyrmex) jamaicensis Ern. André, Rev. d'Entom., Juillet, 1893, p. 149, ☿.

Trachymyrmex sharpii Forel, Trans. Ent. Soc. London, 1893, Pt. IV, Dec. pp. 372, 373, ☿.

Atta (Trachymyrmex) maritima Wheeler, Bull. Am. Mus. Nat. Hist., XXI, 1905, pp. 107–109, pl. vii, figs. 7 and 8, ☿.

Worker. Length: 3.5–4.5 mm.

Head, without the mandibles, as broad as long, somewhat broader behind than in front, with obtusely excised posterior border, rather acute posterior angles and slightly convex sides. Eyes somewhat flattened, in front of the middle of the head. Clypeus with a small sinuate notch in the middle of its anterior border. Frontal area triangular, indistinct. Frontal carinæ with broad subtriangular lobes in front, their surfaces not impressed in the middle, continued back as a pair of diverging ridges to the posterior corners where they meet the postorbital ridges thus enclosing elongated grooves for the antennal scapes. Vertex with a pair of blunt projections and short rows of small tubercles. Each posterior corner of the head with three short blunt spines at the angles of an equilateral triangle. Antennæ slender, scapes somewhat enlarged towards their tips which surpass by less than $\frac{1}{3}$ their length the posterior corners. Pronotum with a blunt, lappet-shaped inferior and a long pointed superior spine on each side. In the middle between the two spines is a small double tubercle. Mesonotum with a pair of robust and rather blunt anterior and a pair of small acute posterior spines. Mesoëpinotal constriction long and rather shallow. Epinotum with subequal base and declivity meeting almost at a right angle, the

former convex in profile, the latter straight; spines long, acute and rather slender, distinctly shorter than the base of the epinotum, directed obliquely upward, backward and outward and continued forward as a pair of blunt, subparallel ridges on the base of the epinotum. All the thoracic spines, except the inferior pronotal pair, covered with small tubercles. Petiole from above oblong, slightly longer than broad, abruptly narrowed anteriorly into a short peduncle; node with four equidistant acute teeth. Postpetiole trapezoidal, more than twice as broad as the petiole, as long as the petiole, as long as broad, semicircularly impressed in the middle behind but with straight, entire posterior border. The border of the impressed region and the sides beset with small tubercles. Gaster suboblong, slightly broadest behind the middle, narrowed in front; first segment with prominent lateral ridges and three broad longitudinal depressions on the dorsal surface. Tubercles small and acute, absent in the median depression and on the ventral surface. Legs long and like the antennal scapes covered with small tubercles.

Mandibles with shining, coarsely punctate blades, more opaque and finely striated at the base. Remainder of body and appendages opaque, granular.

Hairs brownish, very short and curved, longer on the anterior and inferior portions of the head and legs than on the body. Pubescence whitish, very fine and dilute, confined to the antennal funiculi.

Black; mandibles, except the teeth, thorax, petiole, and postpetiole ferruginous or yellowish; pleuræ more or less clouded with black or fuscous; antennæ, legs and apex of gaster dark brown, middle portions of femora and tibiæ often blackish.

Female. Length: 4.5–5 mm.

Head similar to that of the worker. Pronotum with rather blunt inferior and long and pointed superior spines, which are directed outward and forward and slightly upward. Scutellum convex, its posterior edge excised in the middle and with a pair of acute, laterally compressed teeth. Epinotum with short convex base and longer flattened declivity; spines long, slender and acute, directed backward and somewhat outward. Petiole, postpetiole and gaster like those of the worker, but the first broadest in the middle and constricted behind and the second without tubercles on its upper surface. Wings 6 mm. long.

Surface of body coarsely granular; front and vertex rugulose; mesonotum with longitudinal rows of small tubercles.

Pilosity like that of the worker, but longer on the thorax and gaster.

Head and gaster very dark brown; thorax, pedicel, mandibles, antennæ and legs paler, ferruginous. Pleuræ, two triangular spots on the anterior border of the mesonotum, an oblong blotch on the middle of the same region behind, the parapteræ and anterior corners of the scutellum, black or dark brown. Wings smoky brown with darker veins and yellowish costal cell.

Male. Length: 3.5–4.2 mm.

Head small, without the eyes and mandibles nearly as broad as long, with rounded and constricted posterior and very prominent ocellar region. Eyes large and convex, their posterior orbits at the middle of the head. Mandibles acute, denticulate, but rather feeble. Clypeus with straight, entire anterior border. Antennæ very slender; scapes surpassing the posterior corners of the head by about $\frac{1}{2}$ their length. Pronotum with very small, acute superior spines and the inferior spines reduced to angles on the lower border of the segment. Mesonotum and scutellum convex, the former with distinct but shallow Mayrian furrows, the latter

with a pair of small acute teeth on the posterior border. Epinotum with short, convex base and longer sloping and concave declivity; spines short, acute, not longer than the base and hardly longer than broad at their insertions. Petiole and postpetiole like those of the worker, but the former narrowed behind the middle and the latter with more obscure tubercles. Gaster elliptical, broadest in the middle tapering behind, without depressions and ridges on the first segment and with very minute piligerous tubercles on both the dorsal and ventral surfaces. Genitalia small and retracted. Legs very slender, without tubercles; terminal tarsal joint slightly enlarged. Wings large, 5.5 mm. long.

Whole body and appendages opaque, minutely granular; head finely and longitudinally rugulose behind. Mesonotum with longitudinal rows of shallow oblong depressions or foveolæ. Mesopleuræ feebly rugulose.

Hairs like those of the worker and female, but finer, straighter and more appressed on the legs and antennæ.

Dull, rather light ferruginous; posterior portion of head, Mayrian furrows, lateral borders and a large oblong spot on the posteromedian portion of the mesonotum, paraptera and sides of the scutellum black. Wings like those of the female.

West Indies: Jamaica (T. D. A. Cockerell); St. Vincent (H. Smith); Andros and New Providence Is., Bahamas (Wheeler); Culebra (Wheeler).

I believe there can be no doubt that Forel's *T. sharpi*, André's *jamaicensis* and my *maritima* are all the same species. I have recently found in the collection of the Philadelphia Academy of Sciences a few workers from Jamaica, which agree very closely with André's description and with my specimens of *maritima* from the Bahamas. These, in turn, are almost identical with specimens collected from a greater number of colonies in the island of Culebra. Prof. Forel, to whom specimens from the latter locality were sent, pronounces them to be "indistinguishable from small specimens of *sharpi*." André's name *jamaicensis* must stand, however, as his description was published some six months earlier than Forel's. So far as known, therefore, there is only a single widely distributed species of *Trachymyrmex* in the West Indies, although there is an allied form (*T. urichi* Forel) in Trinidad and a subspecies of this (*fuscatus* Emery) and several distinct species of the subgenus on the adjacent South American continent.

T. jamaicensis is readily distinguished from all of our North American species by the peculiar coloration of the worker and female, the structure of the frontal and postorbital carinæ, the shape of the petiole and postpetiole, etc. The male is peculiar in coloration, the shape of the head, and in having very small, concealed genitalia.

9. **Atta** (**Mycetosoritis**) **hartmanni** subgen. et sp. nov.

Worker. (Pl. XLIX, Figs. 6 and 7.) Length: 1.8–2 mm.

Head, without the mandibles, longer than broad, but little broader behind than

in front, with broadly and obtusely excised posterior margin, subparallel sides and rather acute posterior corners. Eyes moderately convex, just in front of the middle of the head. Mandibles convex, with two large, acute apical and several small and indistinct basal teeth. Clypeus moderately convex, with entire, broadly rounded anterior margin. Frontal area large, triangular, distinct. Frontal carinæ with very large, broad, flattened lobes anteriorly overlapping the insertions of the antennæ. These lobes have acute anterolateral corners and are separated by distinct reëntrant angles from the posterior ridges which are straight, diverging and continued back to the posterior corners of the head. Lateral carinæ continued back only a little behind the eyes where they turn in but fail to meet the frontal carinæ, though leaving a marked groove for the accommodation of the scape and extending to the posterior corner. Antennæ robust, scapes somewhat thickened distally, reaching with their tips to the posterior corners. Thorax long and stout, especially in front, though decidedly narrower than the head. Pronotum without inferior spines, with a pair of obtuse spines at the humeral angles and a pair of tubercles in the middle almost as far apart as each is from a lateral spine. Mesonotum with a blunt ridge on each side, somewhat higher in front and behind than in the middle. These ridges converge rapidly behind and just in front of the deep mesoëpinotal constriction. Epinotum in profile with subequal base and declivity, the former convex, especially in front, with a pair of ridges diverging posteriorly and continued into the small rather blunt spines, which are but little longer than broad at their bases, and directed upward, backward and outward. Epinotal declivity sloping, concave. Petiole from above suboblong, broader than long, a little broader behind than in front where it is suddenly constricted into a short peduncle; node above with a pair of rather acute teeth. Postpetiole 1½ times as broad as the petiole, broader behind than in front, sides slightly rounded, posterior border angularly excised in the middle. Gaster suboblong, broader behind than in front, not impressed in the middle above, anterior and lateral borders straight, the latter with indistinct longitudinal ridges. Legs rather long and stout.

Opaque throughout; mandibles very finely striated, especially at the base. Body very finely granular; front and vertex longitudinally rugulose; first gastric segment covered uniformly with minute tubercles.

Hairs whitish, suberect, curved and short on the body and appendages, longer and more conspicuous on the clypeus and mandibles.

Ferruginous brown; upper surface of head more or less blackish.

Female. Length: 2.5–2.7 mm.

Head resembling that of the worker, anterolateral corners of frontal carinæ more acute; ocelli very small and indistinct. Pronotum large, with a pair of stout, acuminate superior spines directed forward, outward and upward. Mesonotum small, elliptical, flattened, somewhat narrowed in front, with distinct but shallow Mayrian furrows. Scutellum as long as broad, with excised posterior border and acute posterior angles. Epinotum with short, convex base, long concave and vertical declivity and short spines directed backward and outward. Petiole, postpetiole and gaster resembling those of the worker. Wings short (2 mm.) and rounded; venation like that of *Trachymyrmex* and *Cyphomyrmex* but with the inner branch of the cubital and the distal segment of the externomedian veins very faint or obsolete.

Like the worker in sculpture, pilosity and coloration, but with the mesonotum

longitudinally rugulose. Scutellum and paraptera darker than the remainder of the thorax. Wings opaque, fuscous; yellowish towards the base and costal margin.

Male. (Pl. XLIX, Fig. 8.) Length: 2 mm.

Head, without the eyes and mandibles, but little longer than broad, broader behind than in front, with flattened occipital region and a longitudinal ridge on each side of the rather acute posterior corners. Eyes large and convex, the posterior orbits a little behind the middle of the head. Mandibles like those of the worker in shape but smaller and feebler. Clypeus with entire, rounded anterior margin. Lobes of frontal carinæ similar to those of the worker but erect; their posterior ridges short and meeting the lateral carinæ. Scapes very short, extending only a little distance beyond the posterior corners of the head; funicular joints cylindrical, joints 1–7 less than twice as long as broad, terminal joints somewhat longer. Pronotum with short, acute superior spines; inferior spines absent. Mesonotum with distinct Mayrian furrows. Paraptera produced posteriorly as short teeth. Scutellum like that of the female. Epinotum with subequal base and declivity, the former convex, the latter concave; spines about half as long as the base, blunt, somewhat curved, directed upward and outward. Petiole and postpetiole like those of the worker, but the former proportionally longer, the latter broader. Gaster elliptical, median genital appendages digitiform, with blunt tips. Hypopygium with entire rounded posterior margin. Legs rather stout; terminal tarsal joints not enlarged.

Opaque; mandibles and gaster faintly shining; the former very finely, the body more coarsely and densely punctate. Head, thorax and postpetiole also irregularly reticulate-rugulose; first gastric segment above with minute, acute and uniformly distributed tubercles.

Hairs like those of the worker; more distinct and scattered on the gaster.

Head, thorax and pedicel black; first gastric segment very dark brown; remaining gastric segments, mandibles, antennæ and legs light brown or yellowish, antennal scapes, coxæ, and middle portions of the femora infuscated. Wings like those of the female.

Texas: Montopolis and Delvalle, near Austin (Wheeler).

This species which I take pleasure in dedicating to my former pupil, Mr. C. G. Hartmann, who aided me in excavating the nests of this and other Texan Attii, may be regarded either as a degenerate and simplified *Trachymyrmex* or as an aberrant *Cyphomyrmex*. It resembles the species of *Trachymyrmex* in its form and pilosity, while it approaches the species of *Cyphomyrmex* in its small size, the very large lobes of the frontal carinæ, the reduction of the cephalic and thoracic spines and the absence of tubercles on the greater portion of the body. In 1887 (Verh. zool. bot. Ges. Wien, XXXVII pp. 561, 562) Mayr described an aberrant female Attiine ant from Brazil as *Cyphomyrmex asper*, which, though considerably larger than the above described species, would seem nevertheless to belong to the same subgenus. More recently Emery (Bull. Soc. Ent. Ital., XXXVI, 1905, pp. 162, 163) has described and figured a single worker specimen from Chubut, Argentina, as dubiously referable to Mayr's species. This specimen meas-

ures 3 mm. in length and has no reëntrant notch between the anterior lobular and posterior ridge-like portions of the frontal carinæ, and the shape of the thorax appears to differ considerably from that of *hartmanni*. Emery, to whom I sent some workers of this latter form, says, however, that both species "connetano tra loro i generi *Atta* e *Cyphomyrmex*; é dubbio a quale dei due convenga meglio assegnarli." As I shall show in the latter part of this paper, the habits of *hartmanni* are much more like those of *Trachymyrmex* than *Cyphomyrmex*, so that the subgenus *Mycetosoritis*, which I have erected for this species and *aspera* Mayr, belongs rather with *Atta* s. lat. *M. hartmanni* should be regarded as the type of this subgenus as Mayr's species is so imperfectly known.

10. **Atta (Mycocepurus) smithi** *Forel.*

Atta (*Mycocepurus*) *smithii* Forel, Trans. Ent. Soc. London. 1893, p. 370. ☿.

Worker. (Pl. XLIX, Figs. 15 and 16.) Length: 2.2–2.5 mm.

Head, without the mandibles, slightly longer than broad, a little broader in front than behind, with obtusely excised posterior border, pointed posterior corners and rather convex sides. There is a distinct though shallow occipital groove. Eyes moderately convex, just behind the middle of the head. Mandibles narrow, acute, with oblique, 5-toothed blades. Clypeus short and broad, with entire, nearly straight anterior border. Frontal carinæ with small rounded lobes, very close together and separated only by a narrow, cuneate groove; they are continued behind as low diverging ridges which fade away before reaching the posterior corners. Postorbital carinæ indistinct, reaching the posterior corners but not including with the frontal ridges distinct grooves for the accommodation of the antennal scapes. Scapes much shorter than the funiculi, slightly thickened towards their tips, which barely surpass the posterior corners of the head. Thorax long, in front about $\frac{2}{3}$ as broad as the head, with deep mesoëpinotal constriction. Pronotum without inferior spines, above with four upwardly directed spines arranged in an arc with its convexity directed forward; the two outer spines longest and each with a small acute tooth in front of its base; the inner pair of spines small. Mesonotum also with an arc of four spines but with its convexity directed backward, so that the spines on both segments form a broad ellipse. The anterior mesothoracic spines are longer than the posterior pair. There is also a pair of small projections close together near the anterior borders of the mesonotum and in the middle of the ellipse. Epinotum with the base fully twice as long as the declivity, the former with four successive pairs of spines, the first and third very short and acute, the second longer and the fourth, representing the typical epinotal spines of other Attii, fully as long as the declivity, slender, pointed, directed upward and slightly backward and outward, curved inward at their tips. Metasternum with a small blunt tooth on each side. Petiole from above narrow, fully twice as long as broad, somewhat violin-shaped, broader behind than in front, constricted just in front of the node which is cuboidal, with a concave surface and each of the four upper corners produced into a small spine. In profile its upper surface is horizontal, its anterior slope long and concave. Postpetiole nearly four times as broad as the petiole and nearly as broad as long, campanulate, with

four longitudinal ridges of which the median pair are blunter and separated by a longitudinal groove deepening suddenly at the posterior margin of the segment to form a somewhat circular pit. Gaster much smaller than the head, fully $\frac{1}{3}$ longer than broad, widest posteriorly, with straight sides and anterior border and acute anterior angles. The first segment has a sharp longitudinal ridge on each side but no median depression. Legs long and rather stout.

Opaque throughout; mandibles very finely striated; head above irregularly reticulate-rugose, more coarsely behind than in front. Remainder of body and appendages very finely and obscurely punctate-granular and faintly reticulate, except the gaster which is more distinctly and evenly punctate and slightly roughened on its upper surface. Legs and scapes also slightly scabrous.

Hairs yellowish; very short, curved and sparse, subreclinate, most distinct on the gaster and appendages. Pubescence very fine, whitish, confined to the antennal funiculi.

Yellowish ferruginous; upper surface of head and gaster and the ridges and tips of the spines darker. Mandibular teeth black.

St. Vincent: Bellisle (H. H. Smith).

Cuba.

I have redescribed this species from a type specimen kindly sent me by Professor Forel who has also described a closely related species, *M. gœldii*, from Brazil. The subgenus *Mycocepurus*, as Forel has shown, is related to the other subgenera of *Atta* on the one hand and to *Cyphomyrmex* and *Myrmicocrypta* on the other. It is peculiar and aberrant, however, in its small size, its small, closely approximated frontal lobes and spinulation. Hitherto *M. smithi* has been known only from St. Vincent. I have received specimens from Cuba. Among the materials in my collection I find also a number of workers from two other localities and representing the following varieties:

11. **Atta (Mycocepurus) smithi** var. **borinquenensis** var. nov.

Porto Rico: Vega Baja, Arecibo, Utuado, Monte Mandios (Wheeler).

The workers of this form resemble the type very closely in size, coloration and sculpture but have on each side of the occipital furrow at the postero-median border of the head, a distinct tooth which is nearly as large as the teeth which form the posterior corners. The posterior epinotal spines are curved inward at their tips as in the type.

12. **Atta (Mycocepurus) smithi** var. **tolteca** var. nov.

Mexico: Tuxpan, Jalisco (J. F. McClendon).

Closely resembling the type, but of a yellow color and with straight, more acute and more erect posterior epinotal spines and feebler cephalic

sculpture. The two median occipital teeth of *borinquenensis* are represented by low, pointed ridges.

13. **Cyphomyrmex rimosus** *Spinola.*

Cryptocerus ? rimosus Spinola, Mem. Accad. Sci. Torino (2), XIII, 1851, p. 65 no. 49, ☿ ♂.
Cryptocerus rimosus F. Smith, Trans. Ent. Soc. London (2), II, 7, 1854, p. 223, no. 28.
Meranoplus difformis F. Smith, Catalog. Hymen. Brit. Mus., VI, 1858, p. 195, no. 7, ☿.
Cryptocerus rimosus F. Smith, Trans. Ent. Soc. London (3), I, 4, 1862, p. 409, no. 11, ☿.
Meranoplus difformis F. Smith, Trans. Ent. Soc. London (3), I, 4, 1862, p. 413, no. 7, ☿.
Cyphomyrmex deformis Mayr, Verh. zool. bot. Ges. Wien, XXXVII, 1887, p. 558, ☿ ♀ ♂ (in part).
Cyphomyrmex rimosus Dalla Torre, Catalog. Hymen., VII, 1893, p. 150 (in part).
Cyphomyrmex rimosus Emery, Bull. Soc. Ent. Ital., XXVI, 1894, pp. 88, 89.
Cyphomyrmex rimosus Urich, Trinidad Field Nat. Club, II, no. 7, 1895, p. 181.
Cyphomyrmex rimosus Forel, Biol. Centr.-Am., Hymen., III, 1899–1900, p. 40.

The typical form of this widely distributed and variable species appears to be confined to northern South America and the adjacent mainland of Central America and Mexico. It is represented in my collection by a few worker and female specimens from Grenada, Nicaragua (C. T. Baker) and a number of workers from Manatee, British Honduras (J. D. Johnson). In these specimens the postpetiole of the worker is less than twice as broad as long and the color is of a rich yellowish brown, with the head and posterior portion of the gaster clouded with dark brown. In the female the postpetiole is scarcely broader in proportion to its length and has a perfectly straight posterior border. According to Emery the male has a relatively narrow head, with very acute posterior angles and the postpetiole is less than $1\frac{1}{2}$ times as broad as long. A single worker in my possession from Hayti (P. J. Schmitt) approaches the typical *rimosus* more closely than the Central American specimens, as its thoracic protuberances are longer and more acute and the postpetiole is only $1\frac{1}{2}$ times as broad as long. The following variety, according to Emery (*in litteris*), approaches the typical *rimosus* very closely except in its darker color.

14. **Cyphomyrmex rimosus** var. **comalensis** var. nov.

Worker. (Pl. XLIX, Fig. 1.) Length: 1.8–2 mm.

Head, without the mandibles, longer than broad, much narrower in front than behind, with obtusely excised posterior margin and rather sharply angular posterior

corners. Eyes moderately convex, near the middle of the head. Mandibles small, 5-toothed. Clypeus short on the sides, with a triangular median portion which has a rounded, raised and entire anterior border. Behind it is wedged in between the frontal carinæ which are dilated in front to form two large horizontal lobes impressed in the middle, rounded on the sides, bluntly angular in front and separated at the level of the eye by a reëntrant angle from the posterior ridges. These diverge and extend to the posterior corners of the head where they meet the postorbital ridges and form with them rounded ear-like lobes. Each postorbital ridge is furnished with a blunt but distinct tooth just behind the eye. The frontal and postorbital ridges enclose a deep groove for the accommodation of the antennal scape. Vertex of head with a pair of low, rounded elevations. Antennal scapes robust, thickened towards their tips which extend a little beyond the posterior corners of the head; funiculi slender at the base; joints 2–8 slightly broader than long. Pronotum with four blunt protuberances above in a transverse row, the lateral pair larger and more angular, the inner pair small and closer together than to the lateral pair. Mesonotum a little longer than broad, broader in front than behind, on each side with a blunt ridge, nearly interrupted in the middle so that in certain lights the mesonotum seems to bear two pairs of blunt, elongated elevations. Mesoëpinotal constriction very short and rather deep. Epinotum with a convex base, which is considerably shorter than the sloping, flattened declivity, and with a pair of anteriorly converging ridges. The spines are represented by very small, blunt elevations at the posterior ends of these ridges. Petiole somewhat more than twice as broad as long, flattened above, with rounded sides, only $\frac{2}{3}$ as broad as the postpetiole, which is twice as broad as long, convex in front and with a feeble excision in its posterior border. In front of this excision there is a distinct elongate median depression. Gaster suboblong, somewhat longer than broad, with a very short and indistinct median depression at the anterior border. Legs long and stout; hind femora bent and angularly dilated near the base on the flexor side.

Opaque throughout; mandibles very finely and densely striated; remainder of body minutely granular.

Hairs white, short, scale-like, appressed and uniformly distributed, more slender on the legs than on the body. Pubescence very fine, whitish, confined to the mandibles and funiculi.

Very dark brown, upper surface of head and gaster black, anterior portions of the frontal lobes, antennal scapes and tibiæ dark brown; remainder of legs, funiculi and mandibles light brown.

Female. Length: 2.2–2.4 mm.

Head very similar to that of the worker. Pronotum with pointed inferior angles at the coxal insertions, and above with a pair of blunt angular projections which are as broad at their bases as long. Mesonotum anteriorly with a longitudinal median depression and distinct Mayrian furrows, so that its surface is separated into four slightly convex, elongated areas, two anterior and two posterolateral. Epinotum with very short, convex base and long, abrupt and concave declivity; spines blunt, laterally compressed, shorter than broad at their bases. Scutellum flattened, broader than long; its posterior margin excised in the middle and produced as a broad tooth on each side. Pedicel, gaster and legs similar to those of the worker, but the postpetiole nearly three times as broad as long, with nearly straight posterior border.

Like the worker in sculpture and pilosity.

Head, postpetiole, gaster and appendages colored as in the worker. Thorax dark brown, mesonotum and scutellum blackish, each of the convex areas of the former with a reddish brown spot. Wings opaque, smoky brown, with pale veins.

Male. Length: 2.3 mm.

Head, including the eyes, about as broad as long, with straight posterior border and acute posterior angles. Eyes large and convex, in front of the middle of the head. Ocelli projecting. Mandibles rather slender, with two apical and no basal teeth. Clypeus convex, with very faintly notched anterior border. Lobes of frontal carinæ like those of the worker but erect; posterior ridges obsolete. Antennæ slender; scapes suddenly thickened towards their tips and surpassing the posterior corners of the head by nearly ½ their length; funicular joints cylindrical, less than twice as long as broad except the four terminal joints which are longer; first funicular joint thicker than the others. Thorax similar to that of the female but much more slender; basal surface of epinotum longer; spines short and rather acute. Petiole and postpetiole like those of the worker, but the former segment is proportionally longer and the latter has the median depression further forward. Gaster elliptical, slightly flattened; first segment in front with a narrow, faintly impressed line. Genitalia retracted. Legs slender; hind femora without a triangular projection on the flexor side.

Opaque; gaster finely shagreened and distinctly shining.

Appressed white hairs less scale-like and conspicuous than in the worker and female, especially on the gaster; very short on the legs and antennal scapes.

Coloration similar to that of the worker; terminal gastric segments, legs and antennæ dull yellowish brown. Wings as in the female.

Texas: Sources of the Comal River at New Braunfels (Wheeler).

15. **Cyphomyrmex rimosus** var. **fuscus** *Emery.*

Emery, Bull. Soc. Ent. Ital., XXVI, 1894, p. 89, ☿ ♀ ♂.

In this variety, described from Santa Catharina, Brazil, all three phases are "entirely brown; mandibles, funiculi and articulations reddish; stature a little more robust" than the typical form.

16. **Cyphomyrmex rimosus** var. **major** *Forel.*

Forel, Ann. Soc. Ent. Belg. XLV, 1901, p. 125. ☿.

In the worker of this variety from Guatemala the stature is somewhat larger (2.7–2.8 mm.) than that of the typical form, the ear-like corners of the head longer and the thoracic ridges and projections more prominent.

17. **Cyphomyrmex rimosus minutus** *Mayr.*

Cyphomyrmex minutus Mayr, Verh. zool. bot. Ges. Wien, XII, 1862, p. 691 no. 1 ☿.
Cataulacus deformis Roger, Berl. entom. Zeitschr., VII, 1863, p. 210, no. 104, ♀ ♂.
Cyphomyrmex steinheili Forel, Bull. Soc. Vaud. Sc. Nat. (2) XX, 91, 1884, p. 368, ☿,
Cyphomyrmex deformis Mayr, Verh. zool. bot. Ges. Wien, XXXVIII, 1887, p. 558, ☿ ♀ ♂ (in part).
Cyphomyrmex rimosus Dalla Torre, Catalog. Hymen., VII, 1893, p. 150 (in part).
Cyphomyrmex rimosus Forel, Trans. Ent. Soc. London, 1893, Pt. IV, p. 374.
Cyphomyrmex rimosus subsp. *minutus* Emery, Bull. Soc. Ent. Ital., XXVI, 1894, p. 89, ☿ ♂.
Cyphomyrmex rimosus Forel, Biol. Centr.-Am., Hymen., III, 1899–1900, p. 40 (in part).
Cyphomyrmex rimosus subsp. *minutus* Wheeler, Bull. Am. Mus. Nat. Hist., XXI, 1905, p. 106, figs. N. and O.

Venezuela: Cayenne (Emery).

West Indies: Cuba (Mayr); St. Vincent (H. H. Smith); New Providence, Bahamas (Wheeler); Culebra and Porto Rico (Wheeler).

Florida: Planter, Key Largo (Wheeler).

This subspecies which is confined to the West Indies and adjacent shores of North and South America, appears to differ very slightly from the typical form of the species and the var. *comalensis*. The worker is somewhat smaller and often of a paler color, with the thoracic projections more feebly developed and more rounded and the vestiges of the epinotal spines even more insignificant. Both the petiole and postpetiole are considerably broader, each being fully twice as broad as long. According to Emery the male of *minutus* has the head rounded behind, but my specimens from the Bahamas and Porto Rico have the posterior border of the head straight and the posterior angles projecting as acute teeth. In the female the epinotum is very steep, with small, blunt spines. Forel seems never to have accepted this subspecies, and I am myself very doubtful whether it deserves to rank as such. It is certainly much less distinct and less easily recognizable than the following:

18. **Cyphomyrmex rimosus dentatus** *Forel.*

Cyphomyrmex rimosus race *dentatus* Forel, Ann. Soc. Ent. Belg., XLV, 1901, p. 124 ☿.
Cyphomyrmex rimosus subsp. *dentatus* Wheeler, Ann. Soc. Ent. Belg., XLV, 1901, p. 200.

Mexico: Cuernavaca (Wheeler).

The worker of this marked subspecies is described by Forel as follows: "Differs from the type in that the basal surface of the epinotum has two distinct teeth. The pronotal protuberances are stronger, more dentiform. The occipital ears are a little more pronounced than in the type of the species, and especially form a more complete and larger groove for the scape which surpasses them little if at all. Entirely pale ferruginous yellow, with the front and vertex indistinctly brown. The petiole is also broader. The postpetiole has a strong median notch at the middle of its posterior border and its sides are prolonged as dentiform cones which are curved backward. The sculpture is that of *rimosus*, but the gaster has a distinct but very fine system of minute, blunt tubercles. The pubescence is extremely short and very fine, not dilated nor brilliant, so that it is inconspicuous."

Two deälated females of *dentatus* in my collection measure 2.4 mm. in length, and have prominent but blunt and upturned prothoracic spines and strong laterally compressed epinotal teeth; the epinotal declivity is very concave, the posterolateral cones of the postpetiole are more prominent and the median dorsal region of the same segment is more concave than in the worker. The head and thorax are much rougher than in the females of the typical *rimosus* and the gaster is more strongly tubercular, with a short but deep median depression at the base of the first segment. The body is dark brown, the upper surface of the head and thorax blackish and covered with a bluish bloom.

19. **Cyphomyrmex rimosus transversus** *Emery.*

Cyphomyrmex rimosus subsp. *transversus* Emery, Bull. Soc. Ent. Ital., XXVI, 1894, p. 90, ☿ ♀ ♂.

Cyphomyrmex dentatus race *olindanus* Forel, Ann. Soc. Ent. Belg., XLV, 1901, p. 337, ☿.

Cyphomyrmex rimosus transversus Emery, Bull. Soc. Ent. Ital., XXXVIII, 1905, p. 161, ☿ ♀ ♂.

Brazil: Matto Grosso (Emery); Ceara and Olinda (P. J. Schmitt).

The worker of this subspecies resembles *dentatus* in sculpture and in the development of the thoracic projections, but the appressed hairs on the body are broader and more scale-like even than in the typical *rimosus*, the petiole and postpetiole broader, and the median dorsal impression on the latter and on the base of the first gastric segment deeper and longer. The epinotum has blunt but distinct teeth.

In the female the epinotal teeth are very large, compressed and obtuse, the pedicel even broader than in the worker.

The male has the posterior border of the head broadly excised and the posterior corners with acute, slightly recurved teeth. Except in pilosity *transversus* is closely related to *dentatus*, as Forel has observed.

20. **Cyphomyrmex rimosus salvini** *Forel.*

Cyphomyrmex rimosus race *salvini* Forel, Biol. Centr.-Am., Hymen., III, 1899–1900, p. 40, pl. iii, fig. 2. ♀.

Forel described only the female of this form from a specimen taken at Bugaba, Panama. The late Dr. F. C. Paulmier brought me from Port Limon, Costa Rica two males and several workers which seem to me to belong to this same form. The worker is larger than that of any of the other subspecies of *rimosus*, measuring nearly 2.5 mm. The frontal lobes are very large and concave, the ear-like corners of the head much prolonged and pointed. The thoracic projections, especially the anterior pronotal pair, are long and acute, the epinotal teeth very faintly indicated. The petiole is more than twice as broad as long, the postpetiole about 1½ times as broad as long, with excised posterior margin and a posteromedian impression. There is also a distinct median impression at the base of the gaster. The hairs are much flattened and scale-like, pearly white and abundant, appressed on the body, but reclinate or even suberect on the legs and scapes. The body is light chocolate brown, the legs and antennæ paler.

The female according to Forel's description, measures 3.7 mm. and is very similar to the worker in the shape of the head. The superior pronotal teeth are stout and triangular, the epinotal teeth much reduced. The postpetiole is proportionally broader than in the worker, the gaster very convex, feebly marginate on the sides and without any indications of depressions and elevations.

The male, too, is decidedly larger than the corresponding sex in other forms of *rimosus*, measuring nearly 3 mm. in length. The superior occipital teeth are short and acute, the superior pronotal pair blunt and rather slender. In the place of the spines, the epinotum has a pair of broad, laterally compressed projections, which are continued forward and backward on the base and declivity as prominent ridges. The hairs on the body and appendages are all appressed and not very abundant, not dilated on the legs and only slightly scale-like on the body. The latter is chocolate brown like that of the worker, with the first gastric segment blackish, the mandibles, clypeus, frontal lobes, antennæ, legs, terminal gastric segments and genitalia dull yellow. The wings are very dark brown or blackish.

21. **Cyphomyrmex wheeleri** *Forel.*

Forel, Bull. Soc. Ent. Suisse, X, 7, 1900, pp. 282–284, ☿ ♀.

Worker. (Pl. XLIX, Fig. 2.) Length: 2.–2.5 mm.

Head, without the mandibles, longer than broad, broader behind than in front, with obtusely excised posterior margin and rather sharp, ear-like posterior corners. Eyes moderately large, convex, at the middle of the head. Mandibles acute, with five sharp teeth. Clypeus with thin, entire anterior border. Frontal area triangular. Frontal carinæ with large, rounded anterior lobes, each with a circular impression, and continued back as a pair of strong, straight, diverging ridges to the posterior corners, where they loop around and become continuous with the postorbital carinæ, thus enclosing deep grooves for the antennal scapes. Each postorbital carina bears a prominent tooth just behind the eye. Vertex with a pair of short longitudinal ridges as far apart as each is from the posterior ridge of a frontal carina and continued laterally along the occipital border to the posterior corner. Here also the 'ears' are joined by a pair of prominent ridges from the posteroinferior surface of the head. Antennal scapes very slender at the base, enlarged towards the tips which reach the posterior corners of the head; joints 2–8 of the funiculus a little broader than long. Pronotum with a pair of acute inferior teeth and above with a larger pair of angular humeral projections and a median pair of smaller projections. Mesonotum elevated in the middle in the form of an elongate elliptical, slightly concave disc, truncated behind, with a faint transverse depression on its posterior portion and bordered with a prominent ridge which is interrupted in the middle in front. Mesoëpinotal constriction short and deep. Epinotum as high as the mesonotum, its base very convex and nearly as long as the concave declivity with which it forms an obtuse angle in profile. Spines laterally compressed, short and triangular, as broad at the base as long, directed backward and continued forward and backward as ridges on the base and declivity. There is also a pair of lateral ridges on the base. Petiole nearly twice as broad as long, as broad in front as behind, with rounded anterior angles; node short, compressed anteroposteriorly, with two spines, directed upward and backward. Postpetiole trapezoidal, 1½ times as broad as the petiole and less than twice as broad as long, with two blunt anterior, two larger and more rounded posterior protuberances and a broad, longitudinal depression in the middle; posterior border entire. Gaster suboblong, distinctly longer than broad, as broad in front as behind; first segment convex above, with distinct lateral ridges and a faint median depression at the base. Tibiæ somewhat compressed; hind femora curved, angularly dilated and compressed near the base on the flexor side.

Opaque throughout; mandibles very finely and indistinctly striated. Remainder of body very finely granular-punctate; antennal grooves and gaster densely and distinctly punctate.

Hairs short, glistening white, scale-like and appressed, uniformly distributed over the appendages and upper surface of the body. Pubescence very fine, whitish, confined to the antennal funiculi.

Yellowish ferruginous; mandibular teeth black.

Female. Length: 2.5–2.7 mm.

Very similar to the worker. Pronotum with prominent inferior and superior teeth, the former acute, the latter larger and blunt. Mesonotum prominent, flat-

tened, with a faint median furrow anteriorly and a pair of broader Mayrian furrows. Scutellum with very broadly and faintly excised posterior border separating a pair of broad, acute teeth. Epinotum with the base convex and only about half as long as the abrupt concave declivity; spines similar to those of the worker but somewhat stouter.

Sculpture and pilosity as in the worker.

Color a little darker in old specimens. Wings opaque, infuscated; the membranes and veins in the anterobasal portion of both fore and hind wings fulvous.

Male. Length: 2.4–2.6 mm.

Head, without the mandibles and eyes, narrow, longer than broad, with straight posterior border. Mandibles like those of the worker but less distinctly denticulate. Frontal carinæ with large, reflected lobes and strong, diverging posterior ridges reaching to the posterior corners where each terminates in a compressed, projecting tooth. Postorbital carinæ absent. Antennæ slender, scapes enlarged towards their tips which surpass the posterior corners of the head by about $\frac{1}{3}$ of their length. Pronotum with indistinct inferior, but prominent and acute superior teeth. Mesonotum with distinct Mayrian furrows. Scutellum like that of the female, but with more deeply excised posterior border. Petiole and postpetiole like those of the worker and female. Gaster elliptical, convex above. Legs long and slender. Hind femora not angularly dilated below.

Opaque; very finely and densely punctate; gaster faintly shining or glossy.

Pilosity very similar to that of the worker and female.

Ferruginous; upper surface of head and the thoracic depressions blackish; basal segment of gaster dark brown above. Mandibles, antennæ, legs and tip of gaster yellowish. Wings like those of the female.

Texas: Austin, Belton, Langtry, Fort Davis (Wheeler).

California: Three Rivers (Culbertson).

The types from which the worker and deälated female were carefully described by Forel, are from Austin. The species is allied to the South American *C. strigatus* Mayr and *C. auritus* Mayr but differs from both in having larger frontal lobes and in lacking prominent ridges on the middle of the first gastric segment. The ear-like posterior corners of the head are much shorter than in *auritus* and the scapes are shorter than in *strigatus*.

22. **Cyphomyrmex flavidus** *Pergande.*

Cyphomyrmex flavidus Pergande, Proc. Calif. Acad. Sci. (2), V, Dec. 1895, p. 895, ☿.
Cyphomyrmex flavidus Forel, Biol. Centr.-Am., Hymen., III, 1899–1900, p. 41.

Worker. Length: 2.2–2.8 mm.

Head, without the mandibles, longer than broad, broader behind than in front, with obtusely excised posterior border and prominent posterior corners. Eyes convex, at the middle of the head. Mandibles small and acute, with oblique, apparently 5–toothed blades. Clypeus long and rather flat, with a minute median excision in its thin anterior border. Frontal area triangular. Lobes of frontal carinæ very

large, horizontal, half as long as the head and extending out laterally a little beyond the borders of the head. Posteriorly each of these lobes has a deep subtriangular depression in its surface. The ridges of the frontal carinæ diverge backward to the posterior corners where they pass over into the postorbital carinæ, not through a rounded arc but rectangularly, so that the termination of the antennal groove is broad and truncated. There is a ridge on each side of the inferior occipital portion of the head and a pair of projections on the vertex, which are continued laterally along the occipital border as a pair of blunt ridges to the posterior corners. Antennal scapes enlarged towards the tips, which extend a little beyond the posterior corners; joints 2–7 of the funiculus a little broader than long. Thorax robust; pronotum with a pair of acute inferior teeth, which are directed forward, and a blunt protuberance on each side above. Mesonotum in the form of an elevated, elliptical and slightly concave disc, bordered with a low ridge which is interrupted in the middle behind and in the middle on each side. This ridge bears a pair of rounded swellings just in front of its lateral interruptions. Mesoëpinotal constriction deep and narrow. Epinotum with a pair of swellings at its base; declivity sloping, longer than the base; spines reduced to a pair of laterally compressed and rather acute teeth which are as long as they are broad at the base. Petiole and postpetiole resembling each other in shape, the former twice as broad as long, broader behind where its sides are produced as a pair of blunt angles; it is flattened above, without spines or teeth and with a small semicircular impression in the middle of its posterior border. Postpetiole $\frac{1}{3}$ broader than the petiole, more than twice as broad as long, rounded in front, with a median groove, broadening behind; posterior margin with three semicircular impressions of which the median is the largest. Gaster longer than broad, suboblong, with straight, feebly marginate sides, rounded anterior and posterior borders, and a short median groove at the base of the first segment. Hind femora curved, with an angular, compressed projection near the base on the flexor side.

Opaque throughout, very finely and densely punctate-granular.

Hairs minute, appressed, slightly dilated, glistening white, rather sparse and indistinct. Pubescence fine, whitish, confined to the antennal funiculi.

Ferruginous yellow; clypeus, frontal lobes, front and middle of vertex more or less brownish; mandibular teeth black.

Mexico: Santiago Ixtquintla, Tepic (Eisen and Vaslit).

This species, which I have redescribed from a type specimen kindly sent me by Mr. Pergande, at first sight closely resembles *C. wheeleri*. It may be distinguished, however, by the absence of teeth on the petiole, the much broader and more truncated ear-like corners of the head, longer antennal scapes and much blunter ridges and projections on the thorax. *C. flavidus* is thus intermediate in several respects between *wheeleri* and *rimosus*, but is undoubtedly a distinct species. Although at present known only from northern Mexico, it may be expected to occur as far north as the southern portions of Arizona and California.

23. **Myrmicocrypta brittoni** sp. nov.

Worker. (Pl. L, Figs. 18 and 19.) Length: 2.3–2.5 mm.

Head, without the mandibles, about as broad as long, slightly broader behind than in front, with obtusely excised posterior border, rather straight sides, rounded posterior corners and a narrow median longitudinal groove. Eyes distinctly in front of the middle, of moderate size and convexity. Mandibles large, convex, with straight outer and inner borders, the latter with about ten teeth which grow gradually smaller towards the base. Clypeus short, with entire, flattened and very broadly rounded anterior border. Frontal carinæ with flattened but slightly reflected lobes, which are much longer than broad, with roundly angular external edges reaching only half the distance between the median line and the external border of the head. Mesially these lobes are fused with the posterior portion of the clypeus and enclose the small, indistinct frontal area which is triangular and longer than broad. The lobes of the frontal carinæ are not continued behind in the form of diverging ridges as in other Attii. Lateral carinæ sharp and distinct, continued to the posterior orbits and bounding a broad, short and deep antennal groove. There are no postorbital carinæ. Antennæ rather slender; scapes slightly curved at the base and enlarged towards their tips, which slightly surpass the posterior corners of the head; funicular joints all considerably longer than broad, terminal joint nearly as long as the four preceding joints together. Thorax long and rather narrow, in front about $\frac{2}{3}$ as broad as the head. Pronotum with small, acute inferior angles. There is a pair of blunt epinotal teeth, but otherwise the thorax is smooth and without spines or projections. Mesoëpinotal constriction distinct, but long and rather shallow. Humeral angles rounded, mesonotum about as long as the pronotum, elongate elliptical, flattened, slightly higher than the epinotum. Epinotum with subequal base and declivity, the former straight and horizontal, the latter concave and sloping, without longitudinal ridges. Metasternum with a small rounded tubercle on each side. Petiole oblong, a little broader than long, with slightly rounded anterior and acute posterior corners; node evenly convex above, suddenly constricted anteriorly into a very short peduncle. Postpetiole nearly twice as broad as the petiole, somewhat broader than long, with straight posterior border, rounded anterior corners and straight, subparallel sides; convex and evenly rounded above without a posteromedian impression. Gaster smaller than the head, longer than broad, elliptical, with straight anterior border and convex upper surface, without lateral ridges or median impression on the first segment. Legs slender, hind femora straight and without an angular projection on the flexor side.

Opaque throughout; mandibles slightly glossy, very finely and densely striated; remainder of body very densely and uniformly punctate.

Hairs short, glistening white, dilated and scale-like, appressed, uniformly distributed over the body and appendages. Antennal funiculi and tarsi with delicate whitish pubescence.

Black; clypeus, antennal grooves, inferior corners of pronotum, antennal scapes, coxæ and legs, dark brown; mandibles, except the teeth, tips of scapes, funiculi, tarsi and articulations of legs light brown or yellowish.

Porto Rico: Santurce (Wheeler).

Though at once recognizable as an Attiine ant, this species is neverthe-

less so unlike any of the species of which I had seen specimens or descriptions that I at first decided to make it the type of a new genus or subgenus. Professor Forel, to whom I sent specimens, has kindly given me a worker of a species which he took some years ago in Colombia. This species, which he will describe as *M. emeryi*, is intermediate in certain characters, such as the structure of the frontal lobes, between the above described *brittoni* and *M. squamosa* F. Smith (= *uncinata* Mayr). *M. emeryi* differs from *brittoni* in having a much longer and more slender thorax, pedicel, legs and antennæ, in being of a lighter (brown) color and in having the appressed hairs on the body and legs, long and not scale-like. The clypeus, lower surfaces of the mandibles and the gula have conspicuously long and projecting hairs. The petiole is nearly twice as long as broad, the postpetiole slightly longer than broad and with a deep rounded excision in the middle of its posterior border. The mandibles are more slender, with more oblique blades and fewer teeth. The epinotal teeth are distinctly longer and directed upward. The frontal carinæ are smaller and the tips of the antennal scapes extend further beyond the posterior corners of the head. According to Mayr's description the thorax in the worker of *squamosa* is furnished with teeth and projections like the more typical Attii. The Porto Rican and Colombian forms therefore approach *Apterostigma* and *Sericomyrmex* much more closely than do the other known species of *Myrmicocrypta* and may be regarded as the simplest and most generalized members of the genus, if not of the whole Attiine tribe. I take great pleasure in dedicating the Porto Rican species to the distinguished botanist, Professor N. L. Britton, with whom I passed many delightful and profitable hours collecting plants and insects in Culebra and Porto Rico.

Part III. Ethological Observations.

1. **Atta texana** Buckley.

In the United States this large "cutting" or "parasol" ant (Fig. 7, and Pl. XLIX, Figs. 11–14), is the only species of the tribe Attii that forms sufficiently populous colonies to be of any economic importance, or, indeed, to be sufficiently common and conspicuous to attract the attention of any one but a myrmecologist. Although unable to determine its exact range, I have found no indications of its occurrence outside of a rather restricted area in Texas. This area appears to have its center at Austin and to comprise the territory for some hundreds of miles north and south in a narrow belt

where there is a moderate annual rain-fall and where the forests are of a mesophytic character. I have never seen it in the dry western portions of the state nor have I heard of its occurrence in the more humid eastern counties, in Louisiana or the other Gulf States. It was seen as far south as Alice in Nueces County, and probably occurs as far north as Waco and Fort Worth. It certainly could not endure the winters of the "Panhandle" region nor even those of the extreme northeastern portion of Texas. Even in the vicinity of Austin large colonies of *Atta texana* are rather sporadic. It prefers the neighborhood of rivers and creeks and especially the rich soil of the pecan and the pure sand or somewhat clayey soil of the post-oak

Fig. 7. *Atta texana* Buckley; male, deälated female, soldier and series of workers; natural size. (Photograph by Messrs. C. T. Brues and A. L. Melander.)

woods. In such spots one is always sure of finding it along the banks of the Colorado, Comal and Guadeloupe Rivers.

The nests are nearly always situated in places fully exposed to the sun, in clearings of the woods, in fields, along roads, etc. In some localities, as at Elgin, I have found them in the sand-ballast of the railway tracks. The nests can be recognized even at a distance as very flat mounds usually not more than one to two dcm. high, with very uneven surface and consisting of sand or soil of a lighter color than the surface of the surrounding country. Closer inspection shows that these mounds, which may cover an area of many square meters, have been derived from the walls of craters,

washed down and fused with one another by the rains. Several perfect and recently constructed craters are commonly found on the top or about the edges of the mound, and in the case of large and active colonies these may be numerous, as in the nest shown in Fig. 8, which was situated on the left bank of the Colorado River between Austin and Montopolis. The craters in this instance covered an area of more than 100 sq. m. although the nest had not been in existence long enough to form a distinct mound. They varied from a dcm. to half a m. in diameter and from a few cm. to a dcm.

Fig. 8. Large *Atta texana* nest on the left bank of the Colorado River between Austin and Montopolis, Texas. (Photograph by Mr. C. G. Hartmann.)

high. Their typical form is shown in Fig. 9, which is taken from the nest represented in the preceding figure. The wall of the crater is often higher on one side than on the others, or it may be crescentic, that is, interrupted at one part of the circumference. The opening at the bottom varies from 3–6 cm. in diameter, is often very irregular in outline and leads vertically or somewhat obliquely downward into a gallery of the same diameter. The large size of the opening is evidently an adaptation for two very different purposes, first, for enabling the ants to carry in their pieces of leaves more

easily, and second, for ventilating the subterranean portions of the nest. In the nests of *Atta texana* I have been unable to detect two kinds of craters, one used as entrances, the other for ejecting the exhausted portions of the fungus gardens, as Forel has observed in the Colombian *Atta cephalotes* and as I have observed at Cuernavaca, Mexico, in the nests of *A. mexicana*. All the craters when fresh, consist of large, uniform pellets of earth or sand, 3–5 mm. in diameter, which are carefully compacted and carried to the surface by the workers. The grains of sand or earth seem to be held together merely by the moisture that permeates the soil at the depth from which they are dug, rather than by any salivary secretion such as von Ihering supposes

Fig. 9. One of the craters of the *Atta texana* nest represented in the preceding figure, about $\frac{1}{6}$ natural size. (Photograph by Mr. C. G. Hartmann.)

the Brazilian *A. sexdens* to employ for this purpose. The pellets disintegrate in the first rain, so that the walls of the craters become lower and more rounded and fuse with one another to form the low mound of older nests. The ants usually work at only a few of the craters at a time, and as only one or two of the openings are used when the ants are busily engaged carrying in leaves, it seems probable that the greater number of craters is constructed for the aëration of the nest and not for entrance or exit.

The depth and extent of the excavations vary, of course, with the size of the colony, its age, and the character of the soil. This is evident from the following notes on three nests examined at different seasons of the year.

April 10, 1900, Messrs. A. L. Melander and C. T. Brues assisted me in excavating a moderately large nest situated at the base of a juniper on the banks of Waller Creek, at Austin. There were at least twenty craters on the summit of the flat mound, which was about 5 m. across. These entrances measuring 2.5–4 cm. in diameter, were found to lead downward as tubular galleries converging towards and uniting with one another more and more, till a depth of about a meter was reached. Here each of the galleries, now greatly reduced in number, entered the top of a large chamber with vaulted roof and level floor. Some of these chambers were fully 30 cm. in diameter and 25 cm. high and as broad as long, others were much elongated. They were sometimes connected with one another by means of broad galleries, especially when lying at different levels. The rootlets of the juniper ran through some of the chambers or hung down freely into their cavities. Each chamber had a large placenta-like gray or white fungus garden covering the greater portion of its floor. Small gardens of a more nodular form also hung suspended, enveloping the juniper roots, which seemed to have been left untouched by the ants, during their excavations, for this very purpose. Each garden was a comb-like or sponge-like mass of triturated leaves and juniper berries, permeated and covered with a mould-like mycelium. This mass exhaled a rather pleasant odor not unlike that of stale honey, and crumbled so readily under the touch that it was impossible to remove it entire. It swarmed with workers, the soldiers being least, the mimims most numerous, whereas the mediæ were intermediate in numbers as well as in size. In one of the gardens we found the aged mother queen of the colony, three winged males, and a number of larvæ. Several of the disintegrated gardens together with many of the ants were carried to the laboratory and placed in large glass jars. By the following morning the insects had completely rebuilt their gardens. The coarser work of carrying and building up the particles of leaf-pulp fell to the lot of the mediæ, while the minims went about planting and pruning the tufts of fungus hyphæ. The huge soldiers merely stalked about on the surface of the gardens, often breaking down under their weight the walls of the delicate comb. The ants were confined in the jars for several days, and after the expiration of a week I made an observation that did not impress me as important at the time: the gardens, which were in a much less flourishing condition than when first installed in the jars, were seen to be covered with droplets of a brown liquid. As these droplets closely resembled those since described by J. Huber (*vide ante*, p. 698) as the excrement of the female *Atta sexdens*, it is probable that the soldiers and mediæ, unable to add fresh leaves to their rapidly deteriorating gardens, resorted to the very same method of manuring the mycelium as that employed by the queen *Atta* while she is founding her colony.

November 3, 1900, I excavated a large nest of *Atta texana* situated on the left bank of the Colorado River about a mile west of Austin. This nest was in pure sand at the edge of a sorghum field about 15 m. above the river bottom where it was overgrown with low willow, pecan and Texas persimmon trees. The ants were busy defoliating the willows and carrying their leafy burdens up the bank and into the nest along a path about 80 m. long. At intervals along this path piles of leaf-clippings, dropped by the ants, lay drying in the sun. The leaves were cut by the mediæ in the manner described by Mœller for the South American *Acromyrmex discigera.* The

Fig. 10. Barton Springs, near Austin, Texas, the classic locality for the study of *Atta texana.* (Photograph by Messrs. Brues and Melander.)

nest was in a promontory accessible from three sides, one of which formed the wall of a small ravine. The craters were very numerous and nearly all on the summit of the bank. The arrangement of the galleries and chambers was very similar to that described for the nest on Waller Creek, except that the chambers were at a lower level (1.5 to 2.3 m.) below the surface and much larger. One of them, of a crescentic form, measured nearly 1 m. in length and 30 cm. broad and high. All of the chambers, of which I examined fully a dozen, were situated in a damper layer of sand than

that overlying them and contained huge fungus-gardens on their flattened floors. These gardens were 10–15 cm. high, of a yellowish color below and made up very largely of triturated sorghum leaves. Above they were bluish or greenish gray and this was the only portion that was permeated and covered with the living mycelium, the lower portions having lost their fungus-nourishing substances. The large amount of this exhausted leaf-pulp still retained in the chambers, showed that *Atta texana* must differ from some of the tropical species of this genus, which carry it to the surface

Fig. 11. Large *Atta texana* nest on the right bank of Barton Creek near Austin, Texas. (Photograph by Messrs. Brues and Melander.)

and eject it from the craters. The Texan species simply keeps on building up its gardens till they reach a considerable thickness while the mycelium retreats to the more nutritive superficial layer. Many of the gardens in the nest under discussion contained worker larvæ and pupæ in abundance, but no sexual forms, either mature or immature. Both in this and in the previously described nest I found many specimens of a little myrmecophilous cockroach, of which I shall have more to say in the sequel. Although the

nest was easily excavated, owing to its location in an exposed bank of pure sand, nevertheless I was made very uncomfortable by the attacks of the soldiers, who actually drew blood with their sharp mandibles.

An interesting nest was excavated and measured by Messrs, Brues and Melander during the spring of 1903. This was situated on the right bank of Barton Creek (Fig. 10) near Austin, about 15 m. above the bed of the stream. In surface view (Fig. 11) it presented a low, irregular mound, con-

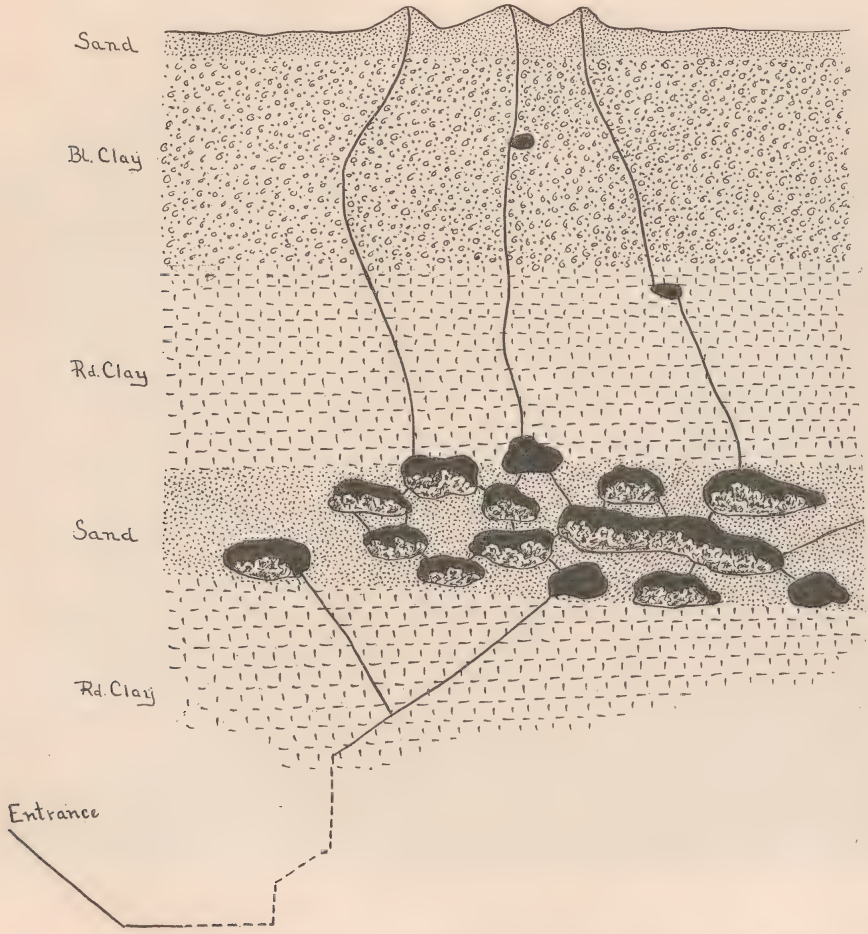

Fig. 12. Diagram of the *Atta texana* nest represented in the preceding figure. (From a sketch by Messrs. Brues and Melander.)

sisting of fused or contiguous craters of pure sand resting on a layer of blue clay. As shown in the diagram, Fig. 12, galleries descended vertically from these craters through the blue clay layer, which was nearly 2 m. thick, and continued down through an equally thick layer of red clay, where they entered a layer of pure sand about a meter in thickness. At the top of this last layer they opened into a number of large chambers communicating with

one another by means of short galleries. The chambers occupied the entire layer, so that the total depth of the nest was very nearly 5 m. Some of the chambers broken open by the pick, are represented in Fig. 13. In the lowermost of these one of the large fungus gardens is seen *in situ* resting on the floor. From the lower series of chambers a number of galleries continued down through another layer of clay, and finally united to form a single long gallery, which ran at first horizontally and parallel with the stream, but finally rose obliquely and opened on the surface of the bank

Fig. 13. Exposed chambers of nest represented in the two preceding figures A large fungus garden is shown *in situ* in the lowermost chamber. (Photograph by Messrs. Brues and Melander.)

a few meters above the water level and at a distance of fully 65 m. from the nest! This remarkable tunnel was the entrance through which the long file of workers brought the leaf-clippings to the chambers. The crater openings on the top of the bank seemed to be used only for excavating and ventilating purposes. That some of these, however, were the original entrances of the nest was proved by the presence of small dilatations or chambers only a few cm. in diameter in the course of the vertical galleries.

These dilatations, two of which are indicated in the diagram, must have represented the chambers of the incipient nest and one of them was undoubtedly the original cell excavated by the mother queen of the colony.

In collecting the vegetable substances to serve as a substratum on which to grow their fungus, the workers of *Atta texana* seem to show no evidences of discrimination, further than that a colony usually concentrates its attention on one kind of material on each of its forays. I have seen workers of the same colony at different times cutting and carrying home the leaves of plants belonging to the most diverse natural orders. They seem indeed to prefer plants with small or rather narrow leaves, but the texture of the leaves is apparently a matter of little importance, for the ants may be seen defoliating soft herbs like the sheep sorrel (*Rumex acetosella*) or the clover, and anon attacking the tough leathery foliage of the live oak (*Quercus virginiana*). But even hard berries like those of the juniper are collected and embedded entire in the gardens. Once I saw a colony carrying away the cracked grains of maize from a hominy mill, and on another occasion the same colony was assiduously gathering large caterpillar droppings that had rained down from a plane tree near the nest. These ants occasionally enter gardens and defoliate rose-bushes or other ornamental shrubs or destroy tender vegetables, but their inability to concentrate their attacks for several consecutive days on particular species of plants, and the somewhat smaller size of their colonies than those of the tropical *Attæ*, make them much less dangerous economically than might be supposed.

Like many other Texan ants, *Atta texana* is more sensitive to the heat than to the sunlight. I infer this from the fact that during the winter and cool autumn and spring months it forages at all times of the day but during the hot summer months carries on its excavations and goes abroad only during the cool night hours. The sensitiveness of these ants to heat and to the humidity of the air is also shown by the fact that they carefully close their nest craters with earth, leaves, or sticks during hot, dry spells. This seems to be an adaptation for preventing the escape of the moisture from the nest through the large ventilating galleries and the consequent injury to the proliferating mycelia in the gardens. While opening the nest chambers of this and other species of Attii I have often seen the delicate fungi wither up within a few moments after exposure to the dry air.

I have not observed in *Atta texana* the method of comminuting the leaf-clippings but there can be little doubt that it is very much like that employed by *A. cephalotes* and *Acromyrmex discigera* as described by Tanner and Mœller. The macroscopic structure of the gardens (Figs. 14 and 15) has been correctly described by McCook (*ante*, p. 679). Their microscopic structure resembles very closely that of the *Acromyrmex* studied by Mœller.

There is the same beautiful, white mycelium with hyphæ .6–.8 μ in diameter everywhere threading and covering the comb-like leaf-pulp and densely dotted with clusters .2–.3 mm. in diameter of the small spherical or pear-shaped food-bodies (Kohlrabiköpfchen) 3–5.5 μ in diameter. As Mœller's terms for these structures are rather far-fetched, since to English-speaking peoples at least the kohlrabi is by no means a familiar vegetable, and as the structures really deserve somewhat more dignified or at any rate more tech-

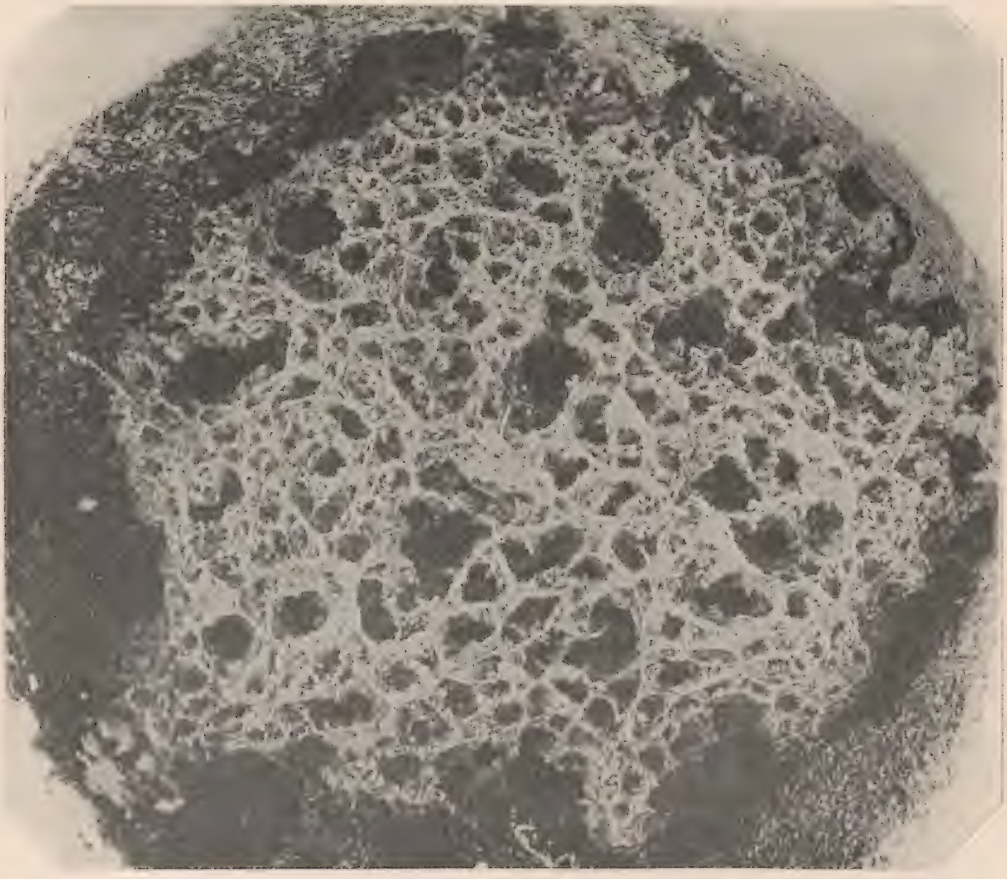

Fig. 14. Entire fungus garden of *Atta texana*, about ¼ natural size. (Photograph by Messrs. Brues and Melander.)

nical appellations, I would suggest that the globular swellings of the hyphæ be called *gongylidia* and the grape-like clusters which they form, *bromatia*. The arrangement of the leaf-pulp at the surface of the gardens in the form of thin walls or plates greatly extends the exposed surface of the substratum, favors the growth of the plant, and thus increases the amount of it that can be raised in a circumscribed cavity. This arrangement also facilitates the control of the fungus and its cultivation and makes it more accessible as food.

Some well-developed means of intercommunication would seem to be necessary for ants like *Atta texana* which live in great colonies and coöperate so intimately both on their foraging expeditions and in the cultivation of their delicate food plant. I am convinced that this means is supplied by the stridulatory organs which are highly developed in all the castes of the species. As I have shown in a former paper,[1] the stridulation of the huge females of *Atta texana* is audible when the insect is held a foot or more from the ear. The male and soldier to be audible must be held somewhat closer, the largest workers still closer, whereas the smaller workers and mimins, though stridulating, as may be seen by the rapid movements of the gaster on the postpetiole, are quite inaudible to the human ear. It is probable that all these

Fig. 15. Portion of fungus garden of *Atta texana* built up by ants in confinement. (Photograph by Messrs. Brues and Melander.)

differences in the rate of vibrations, or humanly speaking, of pitch, correlated as it is with a differentiation in the size and functions of the various castes, is a very important factor in the coöperation of these insects, especially in the often widely separated subterranean cavities in which they spend so much of their lives. Miss Fielde and Prof. Parker [2] have recently given good reasons for concluding that these vibrations are transmitted through the soil or other solids and not through the air, and that they are therefore perceived by the ants through their legs as tactile rather than as

[1] Ethological Observations on an American Ant (Leptothorax Emersoni Wheeler). Arch. f. Psychol. u. Neurol., II, 1903, p. 19, foot-note.

[2] The Reactions of Ants to Material Vibrations. Proc. Acad. Nat. Sci. Phila., Sept. 1904, pp. 642–650.

auditory sensations. This result agrees also with the accounts of others who have investigated the perception of vibrations in insects.

Of all ants the Attii would seem, at first thought, to offer in the great sponge-like masses of decomposing vegetable matter of their fungus gardens the most favorable of resorts for all kinds of myrmecophiles and synœketes. But the number of such animals hitherto observed in the nests of these ants is very small. This is probably due to the exquisite care and diligence with which the ants patrol and cultivate all parts of their gardens to prevent the growth of the aërial hyphæ, alien fungi and bacteria, for under such circumstances any intruder might be easily detected and ruthlessly destroyed. Nevertheless a few animals have managed to secure a foothold in the nests, but so far as known, only in those belonging to species of *Atta* s. str. and *Acromyrmex*. I have never seen any traces of myrmecophiles in the many nests of *Trachymyrmex*, *Mycetosorites* and *Cyphomyrmex* which I have examined. Bates (1892) and Brent (1886) state that certain Amphisbænian lizards manage to live in the *Atta* nests of Brazil and Trinidad. It is probable that these reptiles feed on the ants. Belt (1874) mentions a large *Staphylinid* beetle as occurring on the *Atta* nests of Nicaragua, and Wasmann (1900) concludes that this beetle, which he identifies as *Smilax pilosa* Fabr., is probably a true myrmecophile, because it so closely resembles the large *Atta* workers in its dark brown color and abundant pile. The same author (1894, 1895) mentions several Histerid beetles (*Philister rufulus* Lewis, *Hister* (?) *costatus* Mars, *Reninus salvini* Lewis and *Carcinops* (?) *multistriata* Lewis) as having been taken from the nests of *Atta mexicana*, and three Staphylinidæ belonging to the genera *Aleochara* and *Atheta* from the nests of *A. sexdens*. These are probably all not true guests but synœketes. To the same group belong also a number of specimens of the myriopod *Scutigera* which I found running about in the galleries of an *A. texana* nest.

The only myrmecophiles known to live in intimate relations with Attiine ants are the small and aberrant cockroaches of the genus *Attaphila* of which I described the first species (*A. fungicola*, Pl. LIII, Figs. 47–49) from Texas (1900). This insect, which is very common in the fungus gardens of *A. texana*, measures only 3–3.5 mm. in length. It is yellowish brown and has very small eyes, one-jointed cerci, and peculiar antennæ, consisting of a few cylindrical joints. The females are wingless, the males have vestigial tegmina and hind wings. The antennæ are always imperfect, their terminal joints having been bitten off, in all probability, while the ants are clipping the fungus mycelium. The structure of the remaining antennal joints is so unlike that of all other Blattidæ that *Attaphila* must be regarded as the type of a distinct subfamily, the Attaphilinæ. Since publishing my description of

this singular insect, I have had an opportunity of observing it in artificial nests. It does not feed on the fungus hyphæ as I at first supposed, but mounts the backs of the large soldiers while they are stalking about the garden and licks their surfaces after the manner of some of the myrmecophiles of other ants, notably the little cricket *Myrmecophila nebrascensis*, the Staphylinid beetle *Oxysoma oberthueri*, and the guest ant *Leptothorax emersoni*.

In 1901 Bolivar described a second species of *Attaphila* (*A. bergi*), which

Fig. 16. Nest craters of *Atta* (*Mœllerius*) *versicolor* Pergande in a sandy "draw" at Yucca, Arizona. (Photograph by the author.)

was discovered many years ago by Berg in the nests of *Acromyrmex lundi* in Argentina and Uruguay. This species (Pl. LIII, Figs. 50–54) is very similar to the Texan form and it too, seems always to have multilated antennæ. According to Berg "it is found in the nest of the ants, sitting on the back, neck or even on the head of the sexual individuals (never on the neuters), and when these swarm forth during the spring or summer, it is also carried out of the nests, still attached to its host."

2. **Atta (Mœllerius) versicolor** *Pergande.*

This ant is unquestionably a Mexican species which enters the United States only along its southwestern frontier where it inhabits the arroyo bottoms in the most arid regions. I have observed the typical form of the species only in two localities, at Tucson, Arizona, and at Yucca in the same state, a few miles east of the Californian boundary. At Tucson several colonies were found in an arroyo near the Carnegie Desert Botanical Labora-

Fig. 17. One of the craters of the group represented in the preceding figure, about $\frac{1}{4}$ natural size, showing the difference between the pellets brought up by the ants and the surrounding soil. (Photograph by the author.)

tory where the soil was probably somewhat moist at a depth of several feet, but where the surface was very hard and dry and covered with typical desert plants such as the retama (*Parkinsonia*), the small acacia known as "cat-claw" or "uña de gato" (*Acacia greggi*), the Mexican grease-wood (*Covillæa tridentata*), the ocotillo (*Fouquiera splendens*) and several cacti (*Opuntia*). At Yucca the ants occur in similar arroyos bordered with the beautiful pod-willows (*Chilopsis saligna*) in the midst of a very hot, dry desert, studded

with clumps of cañatilla (*Ephedra*), huge tree-like yuccas, and "allthorn" bushes (*Kœberlinia*). In both localities the nests were surmounted by from one to a dozen craters, varying from 10–30 cm. in diameter, and of very elegant and regular structure (Figs. 16 and 17). This was noticeably the case at Yucca, where the craters were built of the coarse, uniform sand of the arroyo bed. The earth or sand of the crater walls was often of a different color from the surrounding surface, showing that it had been brought up

Fig. 18. Small crater of *Atta* (*Mœllerius*) *versicolor* covered with leaves of grease wood (*Covillœa*) collected by the ants at Tucson, Arizona. These leaves are also scattered along the path leading to the crater (upper right hand corner of figure). (Photograph by the author.)

from a considerable depth. The opening at the bottom of the crater was 2–3 cm. in diameter and was often closed with earth. Even about the open craters no ants were to be seen during the intense heat of the day. Between four and five o'clock in the afternoon, however, they were seen leaving the nests in files, and slowly moving towards some desert shrub in the neighborhood for the purpose of cutting and carrying home its leaves. At Tucson some of the colonies were collecting the entire young and tender leaves of the

"cat-claw," and had completely defoliated some of the bushes (Figs. 18 and 19). Other colonies were carrying in the small leathery leaves and yellow flowers of the grease-wood. Considerable quantities of these leaves had often been gathered and dropped along the path or on the craters, as shown in Fig. 18, and left to wither in the sun when the ants withdrew into their nests during the night or early morning hours.

The colonies were much smaller than those of *Atta texana*, although they

Fig. 19. Acacia bush defoliated by *Atta* (*Mœllerius*) *versicolor* at Tucson, Arizona. (Photograph by the author.)

comprised several hundred workers. These varied considerably in size, especially at Yucca. Dr. William Cannon, director of the Desert Laboratory, kindly assisted me in excavating one of the nests which had only a single crater. The entrance gallery, about 2 cm. in diameter broke up into a number of small anastomosing galleries just beneath the surface and these reunited to form a single gallery extending down into coarse, friable sand to a depth of about a meter and terminating in a single small chamber which contained a fungus garden about the size of a walnut. This garden was

lying on the floor of the chamber and consisted of fine leaf-pulp covered with a brilliant white mycelium dotted with bromatia. No other chambers or galleries could be found, and as the nest contained only about one hundred workers, the colony must have been incipient or enfeebled by age or adverse conditions. As we had spent a great deal of time excavating this nest, and as the heat was intense, so intense, in fact, that it caused the gutta-percha plate-holders of my photographing outfit to soften and crumple, we could not command sufficient energy to excavate a larger and more typical nest. Unfortunately my stay of only a few hours at Yucca did not suffice for the exploration of one of the much finer nests of that locality. Judging from the single nest examined at Tucson, *Mœllerius versicolor* resembles most of the species of *Acromyrmex* described by Mœller, Tanner, von Ihering and Forel in having only a single chamber and garden.

My notes on the subsp. *chisosensis* are even more fragmentary. At Terlingua, Texas, in the Great Bend of the Rio Grande, I found a few dead workers of this form in a spider's web under a stone, but was quite unable to locate the nest from which they came. Judge O. W. Williams, however, brought me a number of fresh specimens from a nest in a dry arroyo at the foot of the Chisos Mountains some miles southeast of Terlingua. Both localities are in very arid deserts, riven with cañons, though the vegetation is of a different type from that of southern Arizona. The red quicksilver-bearing soil supports a sparse growth of the sotol (*Dasylirion texanum*), desert spurges (*Euphorbia antisyphilitica* and *Iatropha spathulata*) and lechugilla (*Agave lechugilla*), and the steep cañon walls are spangled with star-like resurrection plants (*Selaginella lepidophylla*) and xerophytic ferns. Such a region, with an annual rainfall of barely 25 cm., is certainly a remarkable environment for an ant compelled to subsist on fungi that can grow only in a humid atmosphere, an ant, moreover, belonging to a group which was probably first developed in the rain-forests of the tropics.

3. **Atta (Trachymyrmex) septentrionalis** *McCook.*

The species of *Trachymyrmex* form small colonies of at most two or three hundred, and often of only a few dozen individuals, and are so timid and retiring in their habits that they are readily overlooked unless their nests happen to be numerous and close together. And even when numerous the nests are not often seen as their earth-works disintegrate and their entrances are kept closed during considerable periods of the year.

Our best known species, *T. septentrionalis*, is widely distributed over the Gulf and South Atlantic States, the var. *obscurior* ranging from central Texas to Florida and the typical form from Maryland to New Jersey. There are no observations to show that either of these forms extends equally far

north in the Mississippi Valley. Mr. Wm. T. Davis has found the typical form as far north as the Raritan River in New Jersey and although he has hitherto failed to take it on Staten Island, it may yet be found in certain parts of Long Island. Both forms of the species have the same habits, although the southern variety often makes larger and more complicated nests and lives in larger colonies than the typical northern form, which is always more or less depauperate, like all ants at the limit of their geographical range. The following description, except in so far as it relates to the size and complexity of the nest, will apply to both forms of the species.

According to my observations, *T. septentrionalis*, even in widely separated localities, always occupies a very precise ethological station. I have never found it except in pure sand and in open woods. It is abundant in the post-oak woods of Texas, especially in the neighborhood of Milano and Montopolis, wherever the red clay is replaced by sand, in the hummocks of Florida (Miami, Jacksonville) and the pine barrens of New Jersey (Lakehurst, Toms River, etc.). The plant associations in all of these localities have a common *facies* in that they always comprise several species of oaks and many other plants and animals peculiar to the Louisianian portion of the Austroriparian subprovince.

Externally the nest of *T. septentrionalis* is very unlike that of any other North American ant known to me. It consists of a little mound of sand varying from 10 to 20 cm. in diameter, and a few cm. in height, of an elliptical, round, or crescentic form and placed at a distance of 5 to 10 cm. from the entrance. The latter is circular and varies from 4 mm. to 1 cm. in diameter, and the gallery into which it leads invariably slopes so as to form an angle with the surface. The sandpile lies in front of the entrance. The external appearance of one of these nests is shown in Fig. 20, from a photograph taken at Lakehurst, where the sand is often covered with the needles, twigs and cones of *Pinus rigida* and *inops*. The subterranean portion of the nest consists of from one to three series of straight galleries alternating with more or less spherical chambers, so that it is possible to distinguish a simple and a racemose type. To the former belong the young nests of the var. *obscurior* and all the nests of the typical *septentrionalis*, whereas the racemose type seems to occur only in old and flourishing colonies of the southern variety.

In the table on page 749 are given the dimensions in cm. of the galleries and chambers of ten nests of *T. septentrionalis* var. *obscurior* examined in three localities about Austin, Texas, nests A to F being of the simple, and G to J of the racemose type. Diagrammatic sections of nests C, D, F, and G–J, drawn to scale, are represented in Pls. LI to LIII, Figs. 37–42, 45. The entrance gallery is called gallery I, that between chambers I and II, gallery II and so on. Of the two measurements recorded for each chamber,

the first is the depth or vertical, the second the breadth or transverse diameter. The chambers are either spherical, or if one diameter exceeds the other, it is most frequently the transverse, so that the chambers are often oblately spheroidal. As the galleries enter and leave the chambers at opposite points on their roofs and floors, the globular cavities have the appearance of being strung on the galleries like beads on a string. The most frequent nests are those of the form A–C, comprising only two galleries and two chambers, and these are the only ones described by previous observers (Morris, McCook, Swingle, Forel). The entrance gallery is commonly a

Fig. 20. Nest of *Atta* (*Trachymyrmex*) *septentrionalis* in pine barren near Lakehurst, New Jersey, about ½ natural size. The circular entrance is in the middle of the figure; the excavated sand is dumped out in a heap in front of it (below). (Photograph by the author.)

few cm. in length and the first chamber is very small (2.8 × 3.2 cm. on an average). These represent the whole of the nest dug by the mother queen while establishing her colony, the other chambers and galleries being added subsequently by the workers. The table and the figures show very clearly that the length of Gal. II and the size of Ch. II, greatly exceed the queen's excavations and are in turn surpassed by subsequent excavations (Gals. III–IV and Chs. III–V). Nests with three, four and five chambers, like D, E, and F, are rarely encountered. Of the last I have seen only a single example and this was peculiar in having Chs. III and IV deeper than broad.

Atta (*Trachymyrmex*) *septentrionalis* McCook

Nest	Gal. I	Ch. I	Gal. II.	Ch. II.	Gal. III.	Ch. III.	Gal. IV.	Ch. IV.	Gal. V.	Ch. V.	Total Depth.
A	2.5	2.5×3.2	7.7	7.7× 7.7	——	——	—	——	—	——	20.4
B	3.8	3.8×4.5	7.7	6.4× 6.4	——	——	—	——	—	——	21.7
C	5.	4. ×4.	5.	6.5× 6.5	——	——	—	——	—	——	20.5
D	2.5	1.9×2.	5.	6.4× 6.5	0.	6.5×10.3	—	——	—	——	22.3
E	3.	3.5×4.	13.5	3.8× 5.	10.2	3.8× 5.	15.3	2.5× 3.8	—	——	55.6
F	1.3	1.3×1.3	1.8	2.5× 2.5	2.5	7.8× 3.8	12.7	12.8×12.	23.	6.4×7.8	72.1
G	2.5	3.8×5.	a. 11.4	a. 6.3× 8.	——	——	—	——	—	——	——
	—	——	b. 2.5	b. 6.3× 9.	5.	5. × 6.4	—	——	—	——	25.1
H	2.5	3.8×5.	a. 7.8	a. 5. × 6.4	——	——	—	——	—	——	——
	—	——	b. 12.8	b. 7.8× 8.3	7.8	3.8× 3.8	—	——	—	——	38.5
I	2.5	2.2×2.2	a. 12.8	a. 7.8× 7.8	a. 7.8	——	—	——	—	——	——
	—	——	b. 7.8	b. 2.5× 3.2	b. 6.4	b. 5. × 7.	12.6	7.7× 8.9	—	——	46.7
J	1.3	1.3×1.3	a. 7.8	a. 6.4× 6.4	a. 5.1	a. 5. × 5.	—	——	—	——	——
	—	——	b. 7.1	b. 7. ×10.2	b. 2.5	b. 7.6× 7.6	—	——	—	——	——
	—	——	c. 8.9	c. 7.6× 7.6	c. 7.6	c. 6.4× 7.6	—	——	—	——	33.1
Ave.	2.7	2.8×3.2	7.9	6.0× 6.7	5.5	5.6× 6.3	13.5	7.6× 8.2	23.	6.4×7.8	35.6

Nest D was unique in having Chs. II and III opening directly into each other. Nests of the simpler racemose type, like G, are more frequent than simple nests with as many as four and five chambers, like D and E. In nests G–I the second gallery sent off a branch terminating in a chamber of its own (Ch. II*a*). The terminal chamber of nest H (Ch. III), like that of nest E (Ch. IV), was very small and obviously in process of being excavated by the ants. In nest I the insects had completed at least a portion of the gallery (Gal. III*a*) leading from Ch. II and the ants, had they been left undisturbed, would probably have widened its end into another chamber (Ch. III*a*). In nest J, the largest and most complicated of the series, not only did Gal. II form two branches, but one of these divided in turn, so that there were three galleries, each terminating in two chambers (Chs. II a, b, c, and Ch. III a, b, c) separated by a gallery (Gals. III a, b, c). Since in all of the nests the galleries formed an angle with the surface of the sand, their total depth, as given in the last column of the table, does not represent the vertical distance of the floor of the terminal chamber from the surface, but the oblique distance from the entrance. Both simple and racemose nests, moreover, though represented in the figures as lying in a single plane, are often bent, or, like nest I, of the latter type, radiate out from the entrance in three different intersecting planes.

When establishing their formicaries the ants select only those spots in the woods where the sand is permeated with fine rootlets. They are careful to leave these untouched, while hollowing out their chambers, as supports for their gardens, which in this, as in other species of *Trachymyrmex*, are always pendent and do not rest on the floor of the chamber like the gardens of *Atta* s. str., *Acromyrmex* and *Mœllerius*. The substratum on which the fungus is grown consists very largely of caterpillar excrement and withered oak-catkins, both picked up under the trees, but often small dead leaves or berries are used, and occasionally as Morris and McCook observed, flowers or green leaves are cut from the small herbaceous plants in the neighborhood. These substances are comminuted and placed on the pendent rootlets where they become knitted together by the rapidly proliferating fungus mycelium. The whole garden then hangs from the roof of the chamber as a cluster of nodular strands or plates separated from the walls and from one another by spaces sufficiently large to admit the ants to all parts of the structure. The first chamber, in which the original worker brood was reared by the queen, is often empty or has lying on its floor particles of exhausted vegetable substances ready to be carried out of the nest, or materials that have just been brought in. This chamber seems to be the work-shop in which the materials are prepared for insertion into the hanging gardens of the lower chambers. The appearance and arrangement of several of these gardens are shown in

Pls. LI–LIII, Figs. 30–46. The mycelium in flourishing colonies has a bluish tint, somewhat like that of *Penicillium glaucum*. The hyphæ measure .78 μ in diameter. The gongylidia are subspherical or pear-shaped, and average 4.5 μ in length and 3.6 μ in breadth, and are grouped in compact clusters or bromatia averaging .4–.5 mm. in diameter.

In Texas the most favorable time to study the nests of *T. obscurior* is during the month of April. Then the ants are actively enlarging and deepening their nests and bringing in supplies for their gardens. While excavating they advance in a small phalanx up the inclined entrance gallery, each laden with a cuboidal sand pellet about 2 mm. in diameter, walk slowly to the sand pile, deposit their burdens and then return for others. The deälated females, of which there may be as many as four or five in a nest, toil in the

Fig. 21. Brood of *Atta* (*Trachymyrmex*) *obscurior*. About twice natural size. Three packets of eggs are shown enveloped in fungus mycelium. (Photograph by Mr. A. Beutenmüller.)

phalanx like the workers. At the slightest alarm the ants immediately retreat into the nest and usually a single worker takes up her position in the entrance and holding a sand-pellet in her jaws, waits patiently till all danger has passed, before venturing forth and leading the troop of her sand-laden sisters. When foraging the ants go out singly and in various directions, pick up what they can find and return with it to the nest, moving slowly and sedately over the sand. The deälated females may also be seen in the act of carrying caterpillar droppings and leaves to the nest. If rudely touched with the finger or a stick, the insect drops her burden, curls herself up, folds her legs and antennæ and "feigns death." At such times her rough yellowish brown body is almost indistinguishable from the sand on which she lies. When the nest is ruthlessly torn open, the ants, especially

if they are numerous and have a large brood, do not feign death but boldly assail the intruder with their mandibles.

The nests remain in fine condition throughout May and the early part of June, while the young are being reared. The eggs are broadly elliptical and embedded in masses in pure white hyphæ. (Fig. 21.) These delicate vegetable strands serve to keep the eggs together, thus enabling the ants to carry them about in packets, afford an admirable protection and, as soon as the larvæ hatch, represent a supply of very accessible food. The older larvæ and young pupæ, however, are always free from adhering hyphæ, so that their surfaces are smooth and glistening, till they develop the rough, tuberculate integument of the adult stage. The brood is undoubtedly

Fig. 22. Nest of *Atta* (*Trachymyrmex*) *septentrionalis* var. *obscurior* in sandy post-oak wood near Delvalle, Texas. About ¼ natural size. This represents the condition of the nest during the dry summer. A few sticks and dead leaves cover the entrance just below the middle of the figure. (Photograph by Mr. C. G. Hartmann.)

moved from chamber to chamber to suit the varying conditions of heat and moisture. Throughout the warm days of May and June it is kept in the superficial apartments. On the morning of June 11, 1903, after an unusually cool night, I found the ants and entire brood of several nests huddled together in the lowermost chambers, but during the warm afternoon of the same day the young had been brought very near the surface. At Miami, Florida, the males and females were mature and ready for the nuptial flight as early as May 9; in Texas I have not seen them in this condition till the second week in June, and to judge from the date on the label of a winged female in my collection the sexual phases of the typical form do not mature in New Jersey till some time in August.

When its nest is disturbed, *T. septentrionalis,* like other Attii is very careful to rescue portions of its fungus gardens as well as its brood. A number of colonies, whose nests I had excavated in the post-oak woods at Montopolis, were found a few days later to have made new nests a few feet from the old sites and to have carried with them such fragments of their gardens as they could rescue. They had suspended these to the rootlets in one or two chambers which they had succeeded in excavating in the meantime, and were busy carrying in caterpillar excrement and withered oak catkins.

During the spring and autumn *T. septentrionalis* may be found abroad at all hours of the day, but with the growing heat of the summer it becomes increasingly crepuscular and nocturnal. And as soon as the dry weather sets in, it greatly contracts or completely closes with dead leaves and twigs the orifice of its nest to reduce or prevent the evaporation of the moisture from the chambers. The sandpile subsides under the influence of the elements till the nest becomes barely distinguishable from the surrounding leaf-strewn surface (Fig. 22). It is then almost impossible to find the nests even in localities where previous exploration has shown them to be very numerous. The ants no longer venture forth but spend all their time weeding and rearranging their gardens in the moist subterranean chambers. Immediately after the first warm rain, however, the nests are reopened, excavations and repairs to the chambers are renewed, the exhausted portions of the gardens are ejected and the ants sally forth in quest of fresh supplies.

4. **Atta** (**Trachymyrmex**) **turrifex** *Wheeler.*

As this species is even more timid and retiring than *T. septentrionalis,* it was some time before I learned to find its colonies and gained an acquaintance with its habits. Its geographical range covers the dry deserts of Trans Pecos Texas, and slightly overlaps the range of *septentrionalis* along the escarpment of the Edwards Plateau in the central portion of the state. That it is a more adaptable ant than its eastern and northern congener, is shown by its occurrence in the following diverse stations:

1. In the treeless deserts at Del Rio, Langtry, Marfa, Alpine and Ft. Stockton, in dry stony soil fully exposed to the glare of the sun. In these localities the colonies are widely scattered.

2. In the clayey soil of the post-oak woods and "cedar-brakes" (*Juniperus sabinoides*) near Austin (Fig. 23), along the Perdenales River, and at Marble Falls. Here the colonies are often numerous and close together.

3. In the pure sand of open fields at Montopolis on the Colorado River. In this locality the colonies are infrequent and mingled with those of *sep-*

Fig. 23. "Cedar Brake" (*Juniperus sabinoides*) near Austin, Texas. Home of *Atta* (*Trachymyrmex*) *turrifex*. (Photograph by Prof. W. L. Bray.)

tentrionalis, a condition which also obtains in sandy portions of the post-oak woods.

Though structurally closely resembling the eastern species, *T. turrifex* may be readily distinguished by a number of ethological characters. Its colonies are much smaller, often consisting of only two or three dozen individuals. Nevertheless a single nest may contain as many as four or five deälated females. The nesting habits are most conveniently studied in the post-oak woods, where the ants prefer to live in the shade of the trees. Here the red clay is overlaid with a stratum of less compact black soil two or three decimeters deep. The external structure of the nest is very different from

Fig. 24. Turret-shaped entrance to nest of *Atta* (*Trachymyrmex*) *turrifex* in a cedar brake near Austin, Texas. (Photograph by Mr. A. L. Melander.)

that of *septentrionalis*. The orifice is only 3–4 mm. in diameter and in typical nests, does not open on the surface of the soil but at the top of a cylindrical turret or chimney about 10 mm. in diameter and from 10–40 mm. high. The walls of this turret, which are made of earth particles, small juniper twigs and other vegetable débris (Fig. 24) are sufficiently resistant to withstand heavy showers. As the nests are often located on sloping ground the turret would seem to be an ingenious adaptation for keeping the water from entering the subterranean galleries and chambers. Occa-

sionally I have found nests with abnormal turrets, like the one represented in Pl. L, Fig. 27, which has the summit enlarged and spreading and provided with three distinct orifices. The pellets of earth brought up by the ants are cuboidal or polyhedral, of uniform size and measure about 2 mm. in diameter. They are not cast to one side as in *septentrionalis* but in a closed circle at a distance of 8–12 cm. from the entrance. As this circle grows in height it forms a very shallow crater with the turret rising abruptly in its center. In the post-oak woods and cedar-brakes the castings are red or dull vermilion and contrast strongly with the black soil or dead leaves of the surface.

The galleries and chambers alternate with one another as in the simple type of *septentrionalis* nests, but the chambers are smaller and the galleries are much longer and usually descend vertically into the soil. These differences are distinctly shown in the figures (Pl. LI, Figs. 33–36) and in the measurements (in cm.) of the accompanying table.

Atta (*Trachymyrmex*) *turrifex* Wheeler.

Nest	Gal. I	Ch. I	Gal. II	Ch. II	Gal. III	Ch. III	Gal. IV	Ch. IV	Gal. V	Ch. V	Total Depth
K	3.7	1.8×1.8	4.2	1.8×2.5	5.	3.8×3.8	6.3	4. ×4.2	7.7	——	38.3
L	1.8	1.3×1.3	8.2	2.8×2.8	9.5	.4×6.5	13.4	3.2×6.5	17.4	4.5×3.8	66.1
M	2.5	.8×1.	11.5	3.2×3.2	14.6	4.2×6.4	15.3	5. ×5.	—	——	57.1
N	3.6	1.3×1.8	6.5	3.5×3.8	11.5	3.8×7.6	7.5	1.5×1.5	—	——	39.2
O	3.6	1.3×1.3	2.5	2.5×5.	12.8	5. ×6.4	7.5	5.2×7.5	—	——	40.4
P	3.8	2.5×2.5	1.5	2.5×3.8	6.3	4. ×5.2	9.	4. ×6.5	10.5	6.5×7.8	50.6
Q	3.5	2.5×2.5	5.	4. ×4.	18.	2. ×2.5	16.5	3.5×5.	15.	——	70.
R	10.2	2. ×2.	23.	5. ×6.4	19.	2.5×3.8	30.5	6.5×7.8	8.	3.8×3.8	110.5
Ave.	4.1	1.7×1.7	7.8	3.8×3.9	12.	3.6×5.2	13.2	4.1×5.5	11.7	4.9×5.1	59.0

All of these nests were located in the clayey soil of the post-oak woods except the last (R) which was in pure sand. Owing to the length of its galleries, this is exceptional in its total depth (110.5 cm.), and therefore abnormally increases the average length of the galleries I to V in the table. The average depth of nests K to Q is only 50.8 cm. which is less than half the depth of nest R. The nests usually comprise four chambers (Fig. 25), but five are often met with, and here, as in *septentrionalis*, the galleries and chambers have their dimensions suddenly increased, below the first chamber, which is the work of the mother queen. I have seen but one *turrifex* nest that resembled the racemose type of *septentrionalis* in having two branches to Gal. IV, each terminating in a chamber. Comparing the nests of the two species we see that both start with the simple, primitive type consisting of

alternating galleries and chambers and that *turrifex* continues its excavations according to this pattern, whereas flourishing colonies of *septentrionalis* change to the racemose type which bears an unmistakable resemblance to the nests of *Atta* s. str.

The greater length of the *turrifex* galleries in pure sand is undoubtedly

Fig. 25. Section of nest of *Atta* (*Trachymyrmex*) *turrifex* showing four chambers exposed (at points of paper triangles numbered 1 to 4). About ¼ natural size. (Photograph by Mr. C. G. Hartmann.)

due to the need of reaching a stratum of greater dampness. In the dry Trans Pecos deserts the same tendency is observable. In that region I repeatedly endeavored to excavate nests, but was never able to reach the chambers on account of the extreme hardness of the stony soil. I am convinced, how-

ever, that these nests were more than a meter deep. That *T. turrifex* requires rather moist soil is also shown by a peculiarity of its nests in the post-oak regions. Here, as I have said, the subsoil is red clay overlaid with a dryer, and more porous black earth. The ants not only carry their excavations down into the subsoil but carefully line the galleries and chambers in the black soil, to the very orifice of the turret, with a thin layer of clay brought up from below. Thus the nest becomes a bottle with thin clay walls, alternately constricted into slender tubes (the galleries) and dilated into ampulliform enlargements (the chambers). This clay lining is probably a very efficient means of preventing both the escape of the moisture from the chambers during dry spells and the entrance during rainy weather of too much moisture from the soil. Unlike the nests of *septentrionalis*, those of *turrifex* are not closed during the dry season. Such closure is in fact unnecessary because the nests are considerably deeper, situated in soil which retains the moisture much longer, and have very small orifices.

The first chamber, like that of the *septentrionalis* nest, is used as a workshop and temporary repository for fresh and discarded vegetable substances. The rootlets of plants are also left dangling into the remaining chambers as a suspensorium for the fungus gardens. These resemble the gardens of *septentrionalis* but are smaller, whiter, and of a more delicate texture, as if the vegetable substratum on which they were grown had been more finely comminuted. In the confection of this substratum the same materials are used, viz., the withered catkins of oaks, the scales of buds, bits of dead leaves and the excrement of caterpillars. I have never seen these ants cutting or bringing in green leaves of any description. At Marfa and Ft. Stockton they were collecting the withered florets of a small yellow composite (*Pectis tenella*). The nest openings were often surrounded by a circlet of these florets, so that to one riding over the desert each nest seemed to be marked by a small handful of saffron. All of the vegetable substances are picked up by the ants from the ground and not collected directly from the plants, as *turrifex* is even less inclined than *septentrionalis* to climb about on the vegetation. The microscopic structure of the fungus gardens is very much like that of *septentrionalis*. The hyphæ measure .78 μ in diameter; the bromatia .3–.4 mm. and consist of beautifully developed gongylidia 3.5–4.7 μ in length and somewhat less in breadth.

The deälated females of *turrifex* take part in excavating and foraging, like the workers. On one occasion, early in the morning of June 14, in the midst of the desert at Marfa, I came upon a whole colony of this ant, comprising some thirty workers and five deälated females, in the act of digging a nest in the hard adobe soil. They had evidently been compelled to forsake their old nest during the night on account of the drought, which was

almost unprecedented even in that region, as it had not rained for nine months. As I have also found many abandoned nests of this ant in the cedar brakes about Austin, I infer that it not infrequently migrates to more favorable spots. It would be interesting to know whether on such occasions the old queens carry over to the new quarters portions of the fungus gardens in their hypopharyngeal pocket, or whether the workers transfer the old gardens piece-meal during the cool night hours. The latter would seem to be the more probable procedure.

T. turrifex is, if anything, slower and more sedate in its movements than *septentrionalis*. It also "feigns death" more readily and never seems to resent the destruction of its nest. Only a few workers are seen at any one time outside the nest. The slightest disturbance causes these to withdraw into the turret, and one may sit motionless near the nest for many minutes before they muster sufficient courage to venture forth again. When several of these ants, together with pieces of their gardens, were placed in a dish with a number of *septentrionalis* workers, a conflict ensued, in which the latter were the aggressors and came off victorious. They carried the *turrifex* garden piece by piece into a wide chamber they had excavated in some sand at the bottom of the dish, but by the following morning they had thrown it all out again and, although they had been without food for several days, they would have nothing to do with it.

The breeding season of *turrifex* must come later in the summer than that of *septentrionalis*. During early June I found a few young larvæ in the nests of the former species, but the only winged female I have seen was captured in flight by Mr. W. H. Long on September 27. I have never been able to obtain a male of this species.

5. **Atta (Trachymyrmex) jamaicensis** *Ern. André.*

Like the preceding two species of *Trachymyrmex*, *T. jamaicensis*, though confined to the West Indies, occurs only in association with a xerophytic flora. It is a larger, much darker ant, with unusually long legs and antennæ. I found it first in the Bahamas, on both Andros and New Providence Islands. On the former it was seen wherever I landed and searched for it—at Big Wood Key, Mangrove Key, on several of the uncharted keys along the course of the Southern Bight and about Crawl Creek. On New Providence it was found in the neighborhood of Fort Charlotte. It prefers to nest in the pure white foraminiferous sand of the sea-beach, at or just above high water mark, along the edges of the 'coppets' which consist very largely of coarse grasses, sea-grape, cocoa-plum, wild sapodilla, sea-lavender and palmettos. Its nest, which is most readily found by tracking foraging

workers, is surmounted by a very flat and obscure crater about 30 cm. in diameter with an oblique and somewhat eccentric orifice 5–10 mm. in diameter. The ants collect buds, small flowers, bits of dead and living leaves and caterpillar excrement as a substratum for their fungus gardens. When rudely touched the workers fall over and "feign death." At first I was inclined to believe that this species is restricted to the sandy seabeaches, but on walking inland about two miles from All Saint's Rectory at Mangrove Key, I found it nesting also in clearings among the 'coppets' wherever a small amount of rich black soil in the cavities of the rough Æolian limestone had induced the negroes to plant maize and other vegetables. Here the ants were busily engaged in cutting and carrying into their nests bits of the green maize leaves after the manner of the species of *Atta* s. str. In other places, like Fort Charlotte, on New Providence Island, the ants were nesting in the dry shady 'coppets.' In all of these localities the nests extended down through holes or crevices in the limestone, so that I was unable to obtain a satisfactory conception of their structure.

On a recent trip to the Island of Culebra, a few miles east of Porto Rico, I again encountered this ant but under conditions more favorable for study. The vegetation on Culebra, which is too low to intercept the rain-laden trade winds from the Atlantic, is decidedly xerophytic. There is no standing water on the island and the short arroyos dry up very soon after a shower. A number of colonies of *T. jamaicensis* were found in the shade of the trees on the banks of these arroyos. The colonies, at the time of my visit (March 2–9), were in an opulent condition and each comprised numerous larvæ, pupæ and winged males and females in addition to about a hundred workers. Externally the nests, though in black friable soil, were like those on the sandy beaches of the Bahamas. Their subterranean structure closely resembled that of the simplest, two-chambered nests of *septentrionalis*. The entrance descended into the soil obliquely and at a distance of 2–3 cm. below the surface, widened into a small spherical chamber 2.5 cm. in diameter. This chamber contained no fungus garden but only a few workers apparently engaged in comminuting leaf clippings and caterpillar excrement. A second gallery 5–10 cm. in length led off obliquely from the bottom of this chamber and terminated in a larger spheroidal cavity 6.5–9 cm. in diameter, filled with a flourishing fungus garden of coarse and nodular structure and suspended from rootlets. The brood, callow and recently matured sexual forms were ensconced among the pendent folds and strands. The mycelium was of a bluish color, like that of *septentrionalis*, with hyphæ .58 μ in diameter. The bromatia measured .36 mm. and consisted of well-developed pyriform gongylidia 4–4.6 μ long and 1.5–3 μ broad.

6. **Atta** (**Mycetosoritis**) **hartmanni** sp. nov.

This interesting little ant was discovered May 9, 1903, in the sandy country on the left bank of the Colorado River at Montopolis and Delvalle, near Austin, Texas, while, with the assistance of Mr. C. G. Hartmann, I was examining and photographing the nests of *Trachymyrmex turrifex* and *septentrionalis*. At first I was inclined to regard the diminutive workers as merely belonging to incipient *Trachymyrmex* colonies, but closer study soon showed that these little ants were not only specifically distinct but also represented a new and interesting subgenus, in certain respects intermediate between *Trachymyrmex* and *Cyphomyrmex*. There were hundreds of their nests, often within a few decimeters of one another, in the fields or in clearings among the oaks and wherever the sand was fully exposed to the sun. These regions were also inhabited by several species of solitary wasps

Fig. 26. Crater of *Atta* (*Mycetosoritis*) *hartmanni* from sandy post-oak woods at Montopolis, Texas. Natural size. (Photograph by Mr. C. G. Hartmann.)

(*Microbembex* and *Pompilus*) and numerous colonies of ants (*Trachymyrmex turrifex* and *septentrionalis*, *Aphænogaster treatæ*, *Pheidole splendidula* and *morrisi*, *Solenopsis geminata*, *Pogonomyrmex comanche*, *Prenolepis arenivaga*, etc.). The herbaceous flora of the region consisted of a sparse growth of bull-nettles (*Iatropha stimulosa*), showy gaillardia (*Gaillardia pulchella*), butterfly weed (*Asclepias tuberosa*), white prickly poppy (*Argemone alba*), stone crop (*Sedum*) and cactus (*Opuntia engelmanni*), all in full bloom.

The nests of the *Mycetosoritis* are small turriform craters of pure sand 5–8 cm. in diameter at the base and tapering rapidly to the summit, which is 2.5–4 cm. high and perforated with a circular orifice barely 2 mm. in diameter (Fig. 26). Occasionally the summit is double (Pl. L, Fig. 28) and furnished with two entrances, which, however, soon unite to form a

single gallery. The internal structure of the nest resembles on a small scale that of *Trachymyrmex turrifex*. It consists of from two to four alternating vertical galleries and spheroidal chambers. As the former are very tenuous and run through pure sand, the excavation of the nests is rather

Fig. 27. Section of nest of *Atta* (*Mycetosoritis*) *hartmanni* in pure sand at Delvalle, Texas. About $\frac{1}{6}$ natural size. (Photograph by Mr. C. G. Hartmann.)

difficult. The measurements of six of these nests (S to X) are given in the accompanying table, diagrams of three of them are represented in Figs. 30–32, Pl. LI, and photographs of portions of one of them in Figs. 27 and 28.

Atta (*Mycetosorites*) *hartmanni* sp. nov.

Nest	Gal. I	Ch. I	Gal. II	Ch. II	Gal. III	Ch. III	Gal. IV	Ch. IV	Total Depth
S.	5.	2. ×2.5	15.	2.6×4.	—	——	—	——	24.6
T.	6.3	1.3×2.	20.5	2.5×4.	18.5	2.5×3.4	—	——	51.6
U.	5.	1.4×1.4	13.	2.5×4.	29.4	2.5×4.5	—	——	53.4
V.	7.6	1.3×1.3	13.3	3.3×3.8	7.	4. ×4.	—	——	36.5
W.	6.	1.2×1.3	18.7	2.3×3.7	20.	2.9×4.1	14	2.×3.4	67.1
X.	5.2	.8×1.5	28.	1. ×3.2	25.3	2.5×4.5	14	2.×3.4	78.8
Ave.	6.5	1.3×1.6	18.1	2.3×3.8	19.8	2.8×4.1	14	2.×3.4	52.1

The galleries are proportionally longer than those of *turrifex* nests in clay or black soil, and the chambers are absolutely smaller and more oblately

Fig. 28. One of the pendent fungus gardens of the nest shown in the preceding figure, slightly enlarged. (Photograph by Mr. C. G. Hartmann.)

spheroidal. On an average, however, the *Mycetosoritis* nests are quite as deep (55.1 cm). Their resemblance to *turrifex* nests in pure sand, like nest

R of the table on p. 756, is greater owing to the elongation of the galleries of the latter species.

Like the species of *Trachymyrmex, M. hartmanni* leaves the rootlets dangling into the chambers as suspensoria for its fungus-gardens (Fig. 28). These gardens, however, have a much more delicate and flocculent texture and are made up almost exclusively of the anthers of plants, knit together by a snow-white mycelium consisting of slender hyphæ .58 μ in diameter. The bromatia, which measure .3–.4 mm. consist of typical pyriform gongylidia 1.5–4.3 μ in length and 1.3–4 μ in breadth.

The colonies are small, not exceeding 60 to 70 workers. Only a single deälated female was found in each of the nests. I was unable to find any

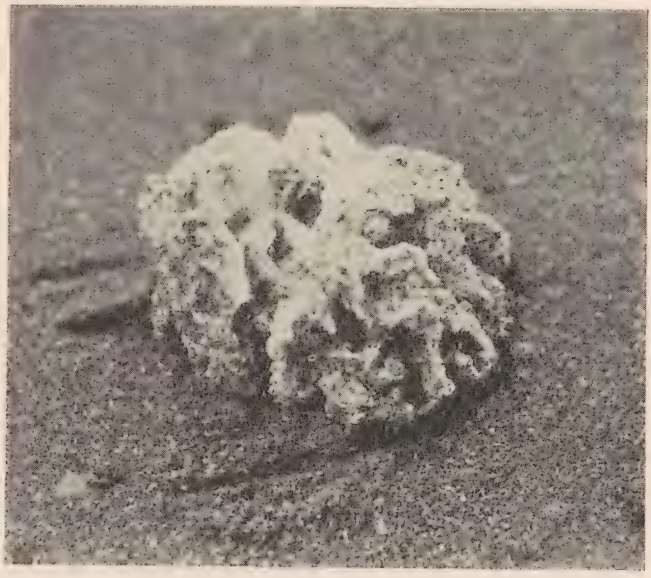

Fig. 29. Fungus garden of *Atta* (*Mycetosoritis*) *hartmanni*, removed from the nest intact and placed on the ground. (Photograph by Mr. C. G. Hartmann.)

larvæ or pupæ. Mr. A. M. Ferguson, who helped me excavate a number of the nests on one occasion, and kept the ants with some of their gardens in an artificial nest, succeeded later in the summer in rearing the males and winged females described on pp. 715–716. The workers are extremely timid and "feign death" with the utmost readiness. Their small rough bodies are then quite indistinguishable from the sand grains among which they lie. Only a few workers forage or excavate at a time. They seek the withered anthers where they have fallen or have been drifted by the wind on the surface of the sand and slowly and laboriously transport them to their nests. These anthers, many of which still contain pollen grains, are inserted entire in the gardens and are evidently responsible for the light and flocculent

texture. Exposure of only a few moments to the air causes the delicate mycelium to wither and contract. The garden of the chamber represented in Fig. 28 was thus dried, but the one in Fig. 29 was photographed immediately after its removal from the nest. The ants appear to be crepuscular or nocturnal. I have not seen them at work after ten o'clock in the morning except on very cloudy days.

On June 5, when I paid a second visit to the sandy country at Montopolis and Delvalle, all the nests were closed and the craters revealed no signs of recent excavation. They had merely crumbled, marking the sites of the nests as obscure little piles of sand. I opened several of the nests and found the workers moving diligently about in their gardens, which were in fine condition. On June 26, when, just before leaving Texas, I paid a final visit to the dry post-oak woods, not a trace of the nests could be found. The wind and rain had completely obliterated the fragile turrets and fused their sandgrains with the surrounding surface, so that even the closest observer would never have suspected the existence of innumerable colonies of little ants diligently cultivating their hanging gardens in the dark bosom of the yellow sands.

The foregoing description of the nests of *Mycetosoritis* shows that this ant is closely related to *Trachymyrmex*. The members of the genus *Cyphomyrmex*, as will be seen from the following accounts of two species have very different habits.

7. **Cyphomyrmex wheeleri** *Forel.*

This species appears to be more widely distributed than most of the preceding, since it ranges from Central Texas to California and probably also over a large portion of northern Mexico. In Texas it is rather rare and, according to my observations, occurs only in arid regions, especially on the Edwards Plateau and Grand Prairie and in the stony deserts of the Trans Pecos country about Langtry and Fort Davis. Although several of the preceding Attii prefer to live in dry localities among plant associations of a more or less xerophytic habitus, the abode of *C. wheeleri* is characterized by even greater aridity. Most of my observations on the habits of this ant were made among the lime-stone hills of the plateau escarpment just west of Austin. Some of these hills, which are often beautifully stratified and terraced and belong to lower cretaceous formations, are shown in Fig. 30, from a photograph taken in the early morning when the long shadows accentuate their peculiar structure. The terraced slopes are strewn with blocks of limestone of different sizes. Among these hills, from early spring to late autumn, the heat and the glare of the sun reflected from the white

Fig. 30. Limestone hills of the Edwards Plateau, near Austin, Texas. Home of *Cyphomyrmex wheeleri*. (Photograph by Prof. W. L. Bray.)

rock are exceedingly oppressive. Water is very scarce and the vegetation is so sparse and stunted or of such a xerophytic character as to yield little shade except in the deeper cañons. The trees and shrubs comprise such species as the mountain cedar (*Juniperus sabinoides*), several hackberries (*Celtis helleri, reticulata* and *pallida,*) oaks (*Quercus fusiformis breviloba* and *schneckii*), buckeyes (*Ungnadia speciosa* and *Æsculus octandra*), dwarf mulberry (*Morus celtidifolia*), dwarf walnut (*Juglans rupestris*), frijolillo, or coral bean (*Sophora secundiflora*), Texas persimmon (*Brayodendron texanum*), madroña (*Arbutus xalapensis* var. *texana*), algerita (*Berberis trifoliata*), *Eysenhardtia amorphoides, Leucophyllum texanum, Rhus microphylla* and *virens,* and *Ephedra antisyphilitica.* During the spring the bare rocks are beautiful with a profusion of smaller plants (*Gilia rigidula, Castilleia, Salvia texana, Stillingia angustifolia, Palafoxia texana, Androstephium violaceum, Camassia fraseri, Yucca rupicola* and *Nolina*)

It is only on the higher and more arid terraces that *C. wheeleri* manages to live and cultivate its fungus gardens, where long after other plants have bloomed and deep into the winter the golden heads of *Actinella scaposa* nod on their long stems. The nests are always under large stones covering a little lingering moisture in the hard soil, which consists very largely of disintegrated limestone. Each colony comprises only a few dozen workers and a single deälated female except during the spring and early summer, when one finds also several callow workers, males and females and a variable number of eggs, larvæ and pupæ. The workers are nocturnal, at least during the warm seasons of the year, a peculiarity which is indicated by their yellow color. They are very slow in their movements and readily "feign death."

The excavations though extensive for such small ants, are unlike those of *Atta, Trachymyrmex* and *Mycetosoritis.* A few rough and occasionally branching galleries about 1–2 cm. in diameter run along the surface covered by the stone, and descend vertically into the ground to a depth of 10–15 cm. One of the surface galleries terminates in a small entrance at the edge of the stone where its opening may be marked by a small crater. Irregular and indistinct dilatations in the galleries represent the chambers of other Attii, and in one of these dilatations, which is often fully exposed when the stone is removed, or may be readily uncovered at a depth of a few cm., the single fungus garden is found. This rests directly on the ground and is spheroidal or ovate, usually about the size of a filbert or pecan nut, more rarely half as large as a hen's egg. It consists of a delicate flocculent substratum made of small vegetable slivers covered with a dense snow white mycelium. The slivers average from 1–3 mm. in length and appear to have been torn from the stems of herbaceous plants. They undergo no trituration or comminu-

tion before they are inserted in the garden. The mycelium which binds these slivers together bears distinct bromatia .6–.7 mm. in diameter and consisting of pear-shaped gongylidia 1.5–3.5 μ in length and .78–1.56 μ broad. They are less globose than the gongylidia of *Atta* and *Trachymyrmex* and less club-shaped than those of the South American species of *Cyphomyrmex* represented in Mœller's figures. Sometimes as in these species, however, they are not terminal but appear as mere swellings in the course of the hyphæ. The brood is embedded in the fungus gardens and the eggs and young larvæ and often also the older larvæ and pupæ are covered with a delicate film of mycelium.

The ants carry all the exhausted particles of the substratum out of the galleries and build them into a flat mass which adheres to the lower surface of the stone. More rarely this refuse is dumped outside the entrance of the nest at the edge of the stone. As the mass of slivers is sometimes nearly as large as a man's hand and therefore greatly exceeds the size of the flourishing gardens, one is compelled to conclude that the vegetable particles contain but little available nutriment for the fungus and have to be continually renewed by the workers. Moreover, as these masses of exhausted substratum are often found under stones covering completely deserted galleries, it is probable that the ants keep moving to new nesting sites. This moving must be necessitated by the small amount of moisture in the soil and the rapidity with which it evaporates even from under large stones.

In the vicinity of Austin, *C. wheeleri* is not confined to the limestone hills of the Edwards Plateau. On three occasions I found small isolated crater nests of this species in the hard pebbly soil of the open woods at a lower altitude in the outskirts of the town. The exhausted substratum was dumped to one side of the small circular entrance which descended vertically into the soil. These nests must have been much deeper than the ones above described as I never succeeded in excavating them completely or in finding the fungus garden.

The males and winged females were found in the nests on the Edwards Plateau June 26th, and as early as June 8th in the somewhat warmer country about Fort Davis. In the latter locality I noticed among the vegetable slivers of the exhausted substratum a number of elytra, thoraces, etc., of small beetles, but whether these insects had been collected for food or merely formed a part of the substratum, I am unable to say.

8. **Cyphomyrmex rimosus** *Spinola.*

The stations inhabited by the various subspecies and varieties of this widely distributed ant afford a striking contrast with the arid environment

of *C. wheeleri* and entail a corresponding contrast in habits. All the forms of *rimosus* that have come under my observation live in the shade of trees and bushes in rather moist, black soil. These ants are, in fact, restricted to such localities on account of the material they require for constructing their gardens and the peculiarities of the fungus which they cultivate. The habits of the subspecies *minutus* which I have had abundant opportunities of observing in the Florida Keys, Bahamas, Culebra and Porto Rico, and those of the subspecies *dentatus* which I first found in the lovely barrancas about Cuernavaca, Mexico, resemble so closely the habits of the var. *comalensis* at New Braunfels, Texas, that I may confine my remarks very largely to this form.

At New Braunfels a number of beautiful springs, the sources of the Comal River, gush forth from the foot of Mission Mountain, one of the limestone hills that constitute the Grand Prairie escarpment (Fig. 31). The volume and temperature of these springs is practically constant during the entire year. They nourish an exuberant vegetation consisting of ash-trees, live-oaks and shittim wood (*Bumelia lycioides*) and a dense undergrowth of subtropical shrubs and herbaceous plants too numerous to mention. The entomologist who enters this undergrowth must be prepared to endure the fiery torments of the "red-bugs" or "coloradillos" ("*Leptus*" *irritans*) and exercise some care lest he tread on a water moccasin. But, if he be in search of ants he will be rewarded by finding a number of interesting subtropical species, among others three species of *Pseudomyrma* (*pallida, brunnea* and *flavida*), a singular little *Strumigenys* (*S. margaritæ* Forel) hitherto known only from the island of St. Vincent, besides the fungus-growing ant with which we are here concerned.

This ant, owing to the close agreement between its color and the black soil over which it moves, is more difficult to detect than any of the other small Attii described in the preceding pages. Single workers wander about slowly in the damp shade of the plants in search of the caterpillar excrement with which they construct their gardens. As soon as one of the short, cylindrical, ribbed pellets is found, the ant seizes it in her jaws, raises it above her head like a man shouldering a cask and returns home with accelerated pace. The slightest touch causes the ant to drop her load, draw up her legs and antennæ and "feign death." And he must have exceptionally good eye-sight who can distinguish her rough, opaque and inert body from the particles of earth among which it falls.

The colonies of *C. comalensis* are larger than those of *C. wheeleri*, sometimes comprising a hundred or more workers and from one to three deälated queens. The nests are under rather small flat stones or pieces of wood, with the entrance sometimes nearly a cm. in diameter, at the periphery. On

Fig. 31. One of the sources of the Comal River at New Braunfels, Texas. Home of *Cyphonygrmus rimosus* var. *comalensis*. (Photograph by Prof. W. L. Bray.)

removing the stone or piece of wood the galleries are seen to be very irregular, running along the surface as in the nests of *C. wheeleri* and extending down into the soil to a depth of 20 to 35 cm. They adapt their course to the many small fragments of limestone on or below the surface. The single fungus garden, of irregularly flattened or sometimes of elongate and straggling form lies in dilated portions of the gallery, usually completely exposed by the removal of the stone. In many nests the garden rests on a small stone, piece of bark or dead leaf from which the earth has been carefully removed by the ants. So different is this garden from that of the other Attii heretofore described that it has been completely overlooked by all previous observers. The substratum consists of a mass of caterpillar droppings a few cm. in diameter, which have undergone so little manipulation by the ants that the individual pellets may be distinctly recognized even to the peculiar ridges produced by the rectal folds of the caterpillars.

The fungus grown on this substratum is not a mycelium as in all the species above described, but is in the form of a number of isolated whitish or yellowish bodies .25–.55 mm. in diameter, of the appearance and consistency of cheese crumbs and of an irregularly polygonal or pyriform shape (Pl. L, Fig. 29). Each of these bodies may be said to correspond to a cluster of gongylidia and may therefore be called a bromatium. It rests with one of its angles or surfaces on the caterpillar excrement, but no rhizoids or mycelial threads can be seen at this point entering and ramifying in the substratum. The whole garden is kept so moist that when first exposed to the air the surface glistens with a film of greenish liquid. As the bromatia rest on this liquid, which evidently represents a thick solution of fecal and vegetable substances, they are in a position to absorb nutriment directly. It is probable that the habit of placing the excrement on the surface of a small stone, bit of wood or dead leaf which happens to be found in the gallery of the nest, is for the purpose of retaining this nutrient moisture and preventing its absorption by the soil. All of these conditions are such as to restrict *C. comalensis* and the other forms of *rimosus* to moist, shady localities. Such situations are of course, also the only ones in which tropical and subtropical plants are sufficiently abundant to furnish an unfailing supply of caterpillar droppings.

When the bromatia are crushed and examined in water under a high power of the microscope, they are seen to consist of a dense mass of elliptical or subspherical cells measuring .78–2 μ in length and .78–1 μ in breadth. Among these there are also cells of other shapes and even smaller sizes as shown in Pl. LII, Fig. 43. The cytoplasm of all of these cells is colorless and finely granular and contains one or more clear vacuoles and a few small refractive corpuscles. A nucleus is probably present, but I have been

unable to find it in my preparations. The cell wall is always very thin and transparent. These cells closely resemble those of the common yeast (*Saccharomyces*) except that they are considerably larger. Like the yeast cells they may often be found in the act of budding or dividing. In this manner probably arise the minute cells scattered about among those of much larger dimensions. All the cells are held together in the bromatial mass merely by cohesion of their surfaces without assuming polyhedral shapes from mutual pressure, and there is no perceptible intercellular substance nor any trace of an envelope enclosing the mass as a whole.

Neither the mycologists with whom I am acquainted nor the botanical works to which I have access, have given me any satisfactory information concerning the natural affinities of this singular fungus. That it must be in a purely vegetative stage of growth will probably be admitted, since there is nothing to suggest sporulation in the structure of the bromatia or the cells of which they consist. It is also evident that this plant must represent an entirely different fungus from any of those described by Mœller. Its cultivation on some artificial medium, such as agar mixed with sterilized extract of caterpillar excrement, may be expected to throw light on its affinities and to show that it belongs to some well known genus or species, but this can be undertaken only by a trained mycologist. It will be a long time, however, before we are in possession of any information in regard to these matters, if botanists continue to manifest as little interest in the fungi cultivated by ants as has been the case during the past fifteen years. In the meantime the singular fungus cultivated by *C. comalensis* and the other forms of *rimosus* over such an extensive area of the American tropics certainly deserves a name, and even at the risk of creating a synonym, I propose to call it *Tyridiomyces formicarum* gen. et sp. nov. and to assign it provisionally to the order Exoaceæ, a group which also includes the well-known yeast fungi.

I have proved that the ants eat the *Tyridiomyces*, by observing their behavior in artificial nests. On several occasions colonies were brought from New Braunfels to Austin, where they were kept in Petri dishes for periods of from one to four weeks and provided with the excrement of caterpillars (*Hyperchiria io*) which feed on the leaves of the southern hackberry (*Celtis mississippiensis*). The captive ants were as careful of the bromatia as of their brood. When the garden was disturbed they rearranged the pellets of excrement and deftly replaced the scattered and detached fungus bodies. Workers, females and males were frequently seen holding these bodies between their forelegs and eagerly rasping off portions of them with their tongues. Sometimes an ant would consume a whole bromatium, but more frequently only a portion was eaten. The irregular polygonal shape

of the bodies is undoubtedly due to this method of feeding. It is equally certain that these bodies keep growing in size and regenerating the consumed portions by a rapid proliferation of their component cells. Caterpillar excrement freshly introduced into the nest was "seeded" by the workers either with entire bromatia brought from older portions of the garden or with small pieces bitten off from the bromatia and sprinkled over the new substratum. In the artificial nests the ants were unable to raise sufficient fungi for their consumption, so that in the course of a few weeks they devoured all of the bromatia and eventually died of starvation. As a rule the substratum employed by *C. comalensis* and the other forms of *rimosus*, that have come under my observation, consists exclusively of caterpillar droppings, but in several of the nests of the subspecies *minutus* in the island of Culebra, I also found small pieces of plant substances which I was unable to identify and a few small decomposing insect larvæ. These were mingled with the caterpillar excrement and also dotted with flourishing bromatia.

On one of my artificial nests of *comalensis* I made an observation which proves that this ant can also eat animal food. Several of the larvæ and pupæ that had been injured while the colony was being captured were eaten with avidity not only by the workers but also by the males and winged females. They did not, however, eat other insects, such as flies and small beetles, which I placed in their nest. The remains of the larvæ and pupæ were eventually inserted among the caterpillar excrement and carefully seeded with pieces of bromatia. This would seem to indicate that the beetle fragments seen in the nests of *C. wheeleri* at Fort Davis may have been similarly employed as a portion of the substratum.

Both in the natural and artificial nests of *C. comalensis* and *minutus* the brood was carefully kept to one side of the damp fungus garden, which would certainly be a very unwholesome and inappropriate nursery compared with the flocculent gardens of other Attii. The larvæ of *comalensis* were fed by the workers with small pieces of the bromatia. I have seen a few virgin females in the nests of this variety as early as May 10, but these and the males were not found in numbers till June 10 to 21. In the more southern countries, such as Culebra and Porto Rico, the winged phases appear as early as March and April. They "feign death" like the workers, but the males less readily than the females.

9. **Atta** (**Mycocepurus**) **smithi** *Forel.*

This species, originally described from the island of St. Vincent, seems to be widely distributed through the West Indies and Mexico, but I have seen it only in Porto Rico, where it is represented by the variety *borinquenen-*

sis. Owing to its retiring habits and small size, it is very easily overlooked. A few isolated nests were found in the open fields and among the cafetals and platanals along the turnpike which winds through the picturesque mountains between Arecibo and Ponce. These nests and one found in the curiously eroded country about Vega Baja between San Juan and Arecibo, were small, obscure craters less than 8 cm. in diameter, made of earth of a different color from that of the surrounding surface and therefore brought up from some little depth. I made several attempts at excavation but was never able to find the fungus gardens. Finally I discovered a nest in moist red clay under a stone on the shady slope of Mount Morales near Utuado at an altitude of about 400 m. The ants, about 30 in number, had constructed a small tubular entrance at the edge of the stone and had excavated a tenuous gallery about 5 mm. in diameter for a distance of several cm. along the surface covered by the stone to a small irregular chamber. In this I found the fungus garden which consisted of a mass, hardly more than 2 c. cm. in volume, of caterpillar droppings, studded with bromatia which differed from those of *Cyphomyrmex rimosus* only in the somewhat greater volume of their component cells (Pl. LIII, Fig. 44). This difference is, however, probably of little importance, as the material from which the figure was drawn was more recently preserved than that represented in Pl. LIII, Fig. 43. As *C. minutus* and *Mycocepurus borinquenensis* occur in the same localities it is quite possible that both ants may cultivate the same species of fungus.

These observations though very meagre, are nevertheless sufficient to prove that in its habits *Mycocepurus* is much more closely related to *Cyphomyrmex* than to any of the subgenera of *Atta.* It would be permissible therefore to regard *Mycocepurus* as an independent genus.

10. **Myrmicocrypta brittoni** sp. nov.

My brief glimpse of the habits of this Porto Rican ant would be hardly worth recording, were it not that no observations have been published on the habits of the remarkable genus *Myrmicocrypta. M. brittoni* was seen only at Santurce, a suburb of San Juan, while I was accompanying Professor N. L. Britton on a botanical excursion. The ants were nesting in the sea-beach just above high-water mark and over a narrow strip of the adjacent shore in a large grove of cocoanut palms. The black workers stood out in strong contrast with the white sand over which they were moving in the bright sunlight. The nests, which were very numerous and often only a few meters apart, resembled those of *Trachymyrmex turrifex* as they were in the form of flat, circular craters, 8–10 cm. in diameter, very shallow in the middle and with the vertical entrance gallery terminating on a small

turret about a centimeter high. Under the palms the sand of the craters was often of a deep red color, unlike that of the surrounding surface, so that the galleries must have been rather deep. Unfortunately my stay in this locality was so brief that I could not examine the nests at my leisure. Although I subsequently collected in many localities on the island, I never again encountered *M. brittoni*. Santurce is, however, easily accessible from San Juan, and the future observer will have no difficulty in finding the nests and of learning much more concerning the habits of this interesting ant.

Part IV. The Attii and the Other Fungus-growing Insects.

Many insects, especially of the orders Coleoptera and Diptera, either in the larval or imaginal stages, are known to feed on fungi, but the ability to cultivate or to control the growth of these food plants is, so far as known, restricted to certain termites, Scolytid beetles and ants. The taxonomic relationships of these three groups to one another are so remote that we are compelled to regard this control as the result of convergent development. In other words, the fungus-growing habit must have arisen independently on three separate occasions in the phyletic history of the Insecta. In order to secure a broader comparative basis for a discussion of the fungus-growing habits of the Attii it will be necessary to summarize our knowledge of the similar habits in the termites and ambrosia beetles.

1. *The Fungus-growing Termites.*

Several observers have undoubtedly seen and described the fungus gardens of termites without being aware of the full significance of their observations. As these gardens are perforated sponge-like masses filled with the insects and their brood and lying on the floors of subterranean chambers, they have often been regarded as the true nests of the termites. The earliest author to call attention to these structures seems to have been König (1779). After describing the vaulted, smooth-walled earthen chambers of *Termes fatalis* at Tanjore, he mentions the gardens full of holes and lying on the floors as being "covered with little knots on their outer and inner surfaces, like chagrin skin. This texture is most clearly seen at their margins near the openings and entrances. Under a magnifying glass they appear fibrous or woolly." In the light of our present knowledge it is evident that this fibrous or woolly appearance was caused by the fungus mycelium.

Smeathman (1781) was the first to recognize the growth covering the garden as being that of a fungus, although he was not aware that it bore any important relation to the insects. In his interesting account of the African *Termes bellicosus* he refers to the gardens as "nurseries." "There is one remarkable circumstance attending the nurseries. They are always slightly overgrown with mould, and plentifully sprinkled with small white globules about the size of a small pin's head. These, at first, Mr. S. took to be the eggs; but on bringing them to the microscope, they evidently appeared to be a species of mushroom, in shape like our eatable mushroom in the young state in which it is pickled. They appear, when whole, white like snow a little thawed and then frozen again, and when bruised seem composed of an infinite number of pellucid particles, approaching to oval forms and difficult to separate; the mouldiness seems likewise to be the same kind of substance. The nurseries are inclosed in chambers of clay, like those which contain the provisions, but much larger. In the early state of the nest they are not larger than a hazel-nut, but in great hills are often as large as a child's head of a year old." I reproduce in Plate LIII, Figs. 55 and 56, Smeathman's figures of a "nursery," and of three of the "mushrooms" enlarged, as these are the earliest known illustrations of the fungus garden of any insect.

Hagen (1860), in his well-known monograph of the Termitidæ, quotes a communication which he received from Nietner of Ceylon on a species referred to *Termes fatalis*. This observer describes the vaulted earthen chambers of the nest and the fungus gardens which they contained. The latter "are hemispherical or broadly conical, flat or concave at the base. They are nowhere attached, but stand out freely in the chambers, from which they may be removed without injury. They consist of a soft bread-like mass of gnawed wood; are brown in color and when broken open golden gray. These nests are always found to be full of minute microscopic fungi, the finest and most beautiful imaginable. The corpuscles, as large as a fine pin's head and composed of small beads, grow in clusters on a net-work of roots and young brood; all resembling crystals of ice or silver." Nietner "does not believe that this fungus bears any other relation to the termites than that the substance of the nest conduces to its growth. The bread-like nests, threaded with fungi, consist of small galleries and cells which often contain so many eggs and young that the whole appears to form one living mass."

Although, as shown by these citations, the termite gardens were known long before those of the ants, their true significance was not understood till after the publication of Mœller's work (1893) on the South American Attii. Holtermann in 1899 made the first careful study of the gardens of *Termes*

taprobanes and *fatalis* in India and the Malay Archipelago (Singapore, Java and Borneo.) He says: "These animals build their nests in the ground; once only did I find them nesting in a log. Notwithstanding their clandestine mode of life, I have been able to investigate hundreds and hundreds of their singular habitations, for I was able to find them easily by means of a species of *Agaricus* which was always rooted in a termite nest. It was only necessary to follow the stem of the pileus into the earth, although in some cases I had to dig to a depth of a meter." Like Nietner, Holtermann refers to the fungus gardens as "nests." These varied from the size of a walnut to that of a man's head and were of a sponge-like structure, full of holes and galleries containing termite eggs, larvæ and nymphs. The gardens were found resting on the floor of the earthen chambers and were separated from the walls by a space as broad as one's finger. They consisted of finely comminuted vegetable substances (portions of dead leaves and stems) that had passed through the bodies of the termites. Under the microscope "the surfaces of the galleries were seen to be covered with a white felt-work of mycelium. Usually the hyphæ were loosely united but sometimes they were combined in strands. The individual hyphæ were richly septate but showed no 'Schnallenbildung' at the septa." Even with the unaided eye Holtermann could detect aërial hyphæ projecting from the general felt-work of the mycelium. "The terminal and often the penultimate cells of these hyphæ were filled with strongly refractive, hyaline protoplasm, whereas the remaining cells contained remarkably little plasma. The terminal cells were often swollen and club-shaped. Sometimes the tip even became spherical but only in its upper portion. In exceptional cases the hyphæ anastomosed, most frequently through confluence of the terminal cells." This mycelium ramified through the whole substratum which it perhaps served to bind together. The swollen tips of the hyphæ were often aggregated to form bromatia like those of *Atta*, but Holtermann failed to find them in all termite colonies, and believes that they may occur only in the gardens of certain species. In addition to these structures he describes others of a more interesting character, namely, small spherical bodies distributed everywhere on the mycelial net-work. They were white, varied from .25–2 mm. in diameter and were usually attached by a peduncle .5–1 mm. in length. The minute structure of these spherules which were not abundant in the interior of the garden, is described as follows: "The peduncle consisting of nearly parallel hyphæ becomes wider below and loses itself in the substratum; otherwise it is of uniform thickness and the head is sharply marked off from its end. The rudiment of the head appears as a distinct thickening at the tip of the stem and as soon as the head is established the stem ceases to grow. In every chamber are found all the transi-

tions from completed heads to their earliest development in the form of a rich branching at the tip of the bundle of hyphæ forming the stem. The otherwise parallel filaments ramify more and more, till the head is formed. It should be noted that the ends of the filaments do not become thinner while branching but always retain the thickness of the general mycelium. The outer cells grow less rapidly than the others and after a time become passive, thus forming an envelope which later appears as a kind of peridium. The limits of the envelope subsequently become more distinct through the gradual drying up of the outer cells. The inner cells, on the contrary, actively proliferate. The head continues to enlarge owing to the numerous ramifications of the hyphæ, till it has become a sac-like apical thickening. With this increase in size its spherical form changes to an oval. Some time before it attains its complete development, a rapid formation of oïdia takes place in its interior, as the hyphæ break up into very short oval cells. Only here and there a few of the main filaments remain intact, but the lateral branches and greater portion of the hyphæ everywhere break up into short rows of oïdia." These oïdia are 8–25 μ long and 6–10 μ broad and have one or two vacuoles in their protoplasm. So complete is this resolution of the hyphæ of the head into oïdia that a slight pressure on the cover glass causes the dry peridium to burst and thousands of oïdia to escape. Holtermann found that the oïdia are eaten by the termites, but he expressly states that these insects also feed on dead leaves, stems, etc. When the insects are removed from the garden, the cavities of the latter become stuffed with masses of aërial hyphæ, the ripe oïdial heads wither up and alien fungi may make their appearance. Holtermann does not believe that the termites are instrumental in preventing these changes under normal conditions since they occur even when termites are present, if the garden is exposed to the light. The normal condition of the gardens may be due to their confinement in dark subterranean chambers, where the spores of alien fungi are unable to germinate. Holtermann is also of the opinion that the above described fungus represents a form of the mushroom which he found growing out of the nests and calls *Agaricus rajap*. This mushroom has an umber-brown pileus and long gray stem. Its spores are rose-red. He succeeded in growing these spores in a culture liquid, but no oïdial heads were produced although the hyphæ sometimes bore club-shaped swellings. Oïdia from the termite gardens were also sown and slowly produced hyphæ with swollen ends and indistinguishable from those grown from the *Agaricus* spores. This is not, however, conclusive proof of the identity of the two fungi, although it seems to be regarded as such by Holtermann.

Karawaiew (1901) has published in Russian an account of this same fungus which he observed at Buitenzorg, Java. His article is accompanied

by some excellent photogravures of the fungus gardens. In Plate LIII, Fig. 57, I have reproduced a portion of one of his figures showing the small oïdial heads apparently of the natural size.

Knuth (1899) observed the fungus gardens of a couple of unidentified species of *Termes* at Buitenzorg, but his description is very meager.

Mme. Errington de la Croix (1900) has published some notes on the Malaccan *Termes carbonarius* which show that the nests of this species contain fungus gardens, although they were not recognized as such. She merely states that they were "formed (perhaps?) by agglomerated eggs in a nutritive substance."

Haviland (1902) figures the nest and gardens of *Termes malayanus* and mentions a number of species of this genus from Africa and southern Asia as fungus growers. These comprise the species of the *bellicosus* group (*T. bellicosus, dives, fatalis, gilvus, azarelli, carbonarius, malaccensis, malayanus, natalensis*), of the *vulgaris* group (*T. vulgaris, angustatus, capensis, taprobanes, badius, latericius*), and of the *incertus* group (*T. incertus* and *pallidus*). Among these are the largest forms of the genus. He states that neoteinic forms, that is, fertile males and females which never develop wings, are not known to occur among fungus-growing termites. The soldiers of some of the species are aggressive and able to make sounds, thus recalling the behavior of the *Atta* soldiers. He says "In the section of the fungus-growers to which *T. bellicosus* belongs the workers run away to their subterranean passages when the nest is being opened, whilst the soldiers stay to defend the nest; generally the smaller soldiers are more active than the larger, for they run about whilst the larger occupy the crevices of the nest and the cavities of the fungus beds, where they wait and bite at anything which comes within reach. The soldiers of this group can generally produce the rattling sound. In this accomplishment, *T. carbonarius* has reached the highest stage of development for the soldiers can hammer in rhythmic unison. At first a few begin irregularly, then they get into time, and the others take it up. Every soldier in the exposed portion of the nest stands up and hammers with its head; the blow is given thrice in very quick succession, and then there is an interval of two seconds. The noise they produce reminded me of wavelets lapping on a shore. This trick of hammering is seen in only a few species; it is clearly a modification of the shaking movements so often seen in workers."

Sjöstedt (1896, 1900, 1903, 1904) has added a number of species to the list of fungus-growing termites from Africa. Such are, for example, *Termes lilljeborgi* and the allied *goliath, gabonensis, nobilis, amplus, gratus* and *vitrialatus*. According to his latest paper (1904) *T. transvaalensis* is also to be included in this series of forms. In his monograph on the African

termites (1900) he figures the gardens of *Eutermes heterodon* and describes them as follows: "May 30, 1891, while digging in a hill-slope near the factory N'dian just beside the water fall of the N'dian River a considerable number of the fungus gardens of this species were unearthed. They were as large as walnuts or somewhat smaller and of a light brownish yellow color. They were scattered about in the earth, some a few inches below the surface, others somewhat deeper. The earth between them was perforated with a net-work of galleries, which connected the different beds with one another. Each of the latter was lying free in a cavity so that the termites could move about over it without obstruction. Only here and there were they attached to the adjacent earthen wall. The nest or fungus garden itself is rather fragile and made up of morel-like, folded, and rounded disks separated by a labyrinth of long ventricose or more rarely rounded cavities. The surface is lumpy and shows that the whole consists of spherical particles. The cavities are filled with milkwhite larvæ, workers, and soldiers, the two latter with yellowish brown heads." Sjöstedt's figures of the gardens of *E. heterodon* are reproduced in Plate LIII, Fgs. 60 and 61.

In 1904 Trägårdh published an interesting account of three fungus-growing termites from the Sudan (*T. natalensis, vulgaris* and *trægardhi*). The first builds large conical earthen mounds .8–2.1 m. in height and 1.4–5.5 m. in diameter at the base. There are no openings on the surface of these mounds, but within they have a number of large chambers, of which only the peripheral ones contain fungus gardens. These are like sponges and conform in shape to the earthen cavities on the floors of which they lie. They are perforated with galleries and consist exclusively of finely comminuted vegetable substances that have been voided and welded together by the insects, for under the microscope they are seen to be made up of pellets that have been flattened into lenticular forms. The fungus growth is described as follows: "Under the microscope the surface of the substratum is seen to be covered with a white felt-work of mycelium and under still higher magnification small hyphæ may be detected. These are aggregated here and there to form small round plates as much as 1 mm. in diameter and consisting of dense branched hyphæ. These apparently correspond to the structures mentioned and described by Holtermann, but differ from these, so far as I have been able to observe, in not having the tips of the hyphæ swollen. Here and there on the inner walls, usually not in any great abundance, but more sporadic, at least in the gardens I have examined, there are small round bodies, which may be as much as 2.5 mm. in diameter. They are of a brilliant white color and are unlike those mentioned by Holtermann in always lacking a peduncle. These spherules are of rather solid consistency and have an external tougher envelope, the whole forming a

compact mass of very much branched and contorted hyphæ. The formation of the oïdia, or process whereby, according to Holtermann, the hyphæ in the interior of the spherules breaks up almost completely into very short oval cells, is by no means so complete in our species. To be sure, the hyphæ are constricted in the interior so that they appear as rows of short oval cells, completely filled with protoplasm, but these cells even in the largest spherules, which have reached their full development, remain attached to one another so that when a thin section is pressed under the cover glass, only a few of the cells escape. In the spherules described by Holtermann, on the contrary, slight pressure on the cover-glass sets free thousands of oïdia."

The mounds of *T. vulgaris* (= *affinis* Trägårdh) are as large as those of *natalensis* (1.4 m. high and 5.5 m. in diameter at the base), but the structure and arrangement of the chambers is very different. They are separated by thick walls and communicate with one another by very tenuous galleries. Each chamber has a flat floor with a peripheral groove and an arched roof. The gardens, which are shaped like inverted dishes and are not confined to the smaller peripheral chambers, are often concave beneath, with a ridge around their border fitting into the circular groove in the floor of the chamber. The substratum consists of the same materials as in *natalensis* and is perforated with numerous transverse galleries. Concerning the fungus Trägårdh says: "The spherules are much smaller than in *natalensis*, are like these nonpedunculate, and occur in great numbers on the walls and especially on the roofs of the cavities and galleries in the peripheral portions of the gardens. These portions are also stuffed with larvæ and nymphs. The spherules are unlike those of *T. natalensis* in structure, since as shown in Figs. 2 & 3 Pl. III [reproduced in the present paper as Figs. 58 & 59, Pl. LIII], the cells in the outer layer of the spherules are larger than those in the interior. Both the inner rows of cells, which ramify dichotomously, and the outer ones, are in part empty, in part filled with finely granular protoplasm." Although Trägårdh found fungus-gardens in the nests of *T. trægardhi* (= *incertus* Trägh.) which seems to live as an inquiline in the nests of *T. bellicosus*, *natalensis* and *vulgaris*, he believes that these had been stolen from the host termites and that *trægardhi* does not itself grow fungi.

Doflein (1905, 1906) has contributed more recent observations on the gardens of termites. He studied colonies of *T. obscuriceps* in Ceylon. The mounds of this species are about 2 m. high and terminate above in one or more huge tubular, chimney-like orifices which open into the galleries and chambers in the interior of the nest. The chambers are about as large as a cocoa-nut or smaller, with smooth walls and excavated to a depth of $1\frac{1}{2}$ m. below the surface. The gardens, which consist of comminuted wood

that has passed through the bodies of the insects, are dish-shaped, and there may be several piled one on top of the other in a single chamber. They are perforated with galleries filled with the termites and their larvæ. "On taking one of these brown cakes in the hand, one can see with the unaided eyes that its whole surface is covered with a fine bloom of fungus mycelium. When broken open the interior of the galleries is found to be covered with peculiar white spherules about as large as a pin-head (1–2 mm. in diam.)." Doflein's description of the minute structure of these spherules is less explicit than that of Holtermann and Trägårdh, but he actually saw the termites swallow these bodies when they were presented on the point of a sterilized needle. They were eaten by the larval workers and soldiers and by the adult kings and queens, but the adult workers and soldiers would not take them. The intestines of the latter contained only comminuted wood in which no fungus elements could be found. Doflein, is, therefore, of the opinion "that in this species the larvæ are fed with a concentrated and easily assimilated food in the form of mycelial spherules, and that these constitute the permanent food of the sexual forms, whereas the larvæ of the workers and soldiers are not fed with these after reaching a certain age but with other substances [dead wood] instead. This suggests the further inference that this food may play an important role in the differentiation of the castes of *Termes obscuriceps* Wasmann."

Doflein found that when the fungus garden of this insect is placed in the light under a bell-jar to protect it from evaporation "the termite fungus can easily be induced to fructify, a peculiarity in which it differs from the fungus cultivated by the South American leaf-cutting ants. In the course of a few days numerous long, club-shaped fruiting organs grow up out of the dense mass of hyphæ, which has developed in the meantime. As time goes on these club-shaped bodies develop pilei, which, as Mr. Green of Peradenyia informs me, are now known to be those of an *Agaricus*, a fact which is also indicated by my own observations. While the fungus is growing up freely in this manner, one is surprised to find alien fungi gradually making their appearance in the garden, and other objects in the neighborhood taking on the usual mouldiness. The tendency of the termite fungus to grow as a pure culture must therefore be very great. This is the case even when very few termites are present. Hence the purity of the culture cannot be ascribed to a ceaseless weeding process carried on by the termite workers, like that assumed by Mœller in the case of the South American *Attæ*."

When the garden is left under the bell-jar the under surface of the latter soon becomes wet, showing that the fungus gives off a great deal of water. In a day or two the termites become suffocated, although masses of these insects hermetically sealed between pairs of watch glasses manage to live in

perfect condition. On raising the bell-jar a peculiar odor is noticeable, which Doflein believes to be a gas fatal to the insects. In the wild nests this gas must be carried off by the chimneys which thus act as ventilating shafts.

All of the foregoing observations relate to Old World Termites. One is naturally led to inquire whether any of the American species raise mushrooms. Haviland was of the opinion that certain of the South American forms such as *T. dirus* are "almost certainly fungus growers." The only observations I have found on the habits of this species are contained in Silvestri's work (1903). He says: "I have seen in the galleries (Fig. 298) pieces of grass 10 mm. long, of leaves 6–10 mm. long and twigs 30 mm. long and 2 mm. in diameter. I have found such materials accumulated in small quantities at various points in the galleries, but I believe that they are not utilized in this form but are brought together in some more subterranean portion of the nest for the development of a fungus on the mycelium of which the termites feed." He found similar vegetable fragments in the nests of *T. grandis* and *molestus*. Of the latter species he says: "I was unable to reach the center of the nest, but I succeeded in finding small masses of grass with the mycelium already developed." From these, which he figures, he concludes that the species grows fungi. But these observations are by no means conclusive as is evident from a comparison with the above cited observations on the Old World species. These do not raise fungi on pieces of dead leaves, twigs, etc., but on finely comminuted particles voided from the alimentary canal and built up in the form of a sponge. Moreover the temporary stores of leaves, etc. which are brought into the nests as food may easily mould when left in the moist galleries. We may conclude therefore that there is really nothing in Silvestri's observations to prove that any of the South American termites eat and grow fungi.

The most important study of the fungus-growing termites has been recently contributed by Petch (1906). Unfortunately I could not consult this work till after the present article had gone to press, so that I am unable to review it at length. Petch carefully investigated the habits and fungus gardens of the Ceylonese *Termes obscuriceps* Wasm. and *T. redemanni* Wasm. In several particulars his account differs from those of Holtermann and Doflein. I quote from the summary of his beautifully illustrated paper the passages relating to the fungi for the purpose of showing how complex and difficult are the problems with which the mycologist is confronted in any critical study of the fungus-growing insects. After describing the sponge-like combs in the chambers of the nest, he says:[1]

"The mycelium on the comb bears small white, stalked or almost sessile

[1] In the quotation I have omitted the numerals belonging to the paragraphs and have run the latter together.

'spheres.' These consist of branching hyphæ bearing either spherical or oval cells. The spherical cells do not germinate. The oval cells germinate readily, but it has not been possible to reproduce the 'spheres' from them. When the comb is old an agaric grows from it. This agaric appears in two forms, one of which has been assigned by various mycologists to *Lentinus, Collybia, Pluteus, Pholiota* and *Flammula,* and the other to *Armillaria.* It develops in a cartilaginous, almost gelatinous, universal veil and is a modified *Volvaria.* Sclerenchymatous cells occur at the base of the agaric stalk and in aborted agarics. It has not been possible to germinate the spores of the agaric or to grow the sphere-producing mycelium from its tissues. When the comb is enclosed in a bell jar, *Xylaria* stromata are produced. Sclerotia may also be formed: the same stromata grow from these. This *Xylaria* is probably *X. nigripes.* The shape of the stroma and conidiophore depend on the age of, and amount of moisture in, the comb. When sown on agar the spores of these reproduce the *Xylaria* stromata. These stromata occur most abundantly in combs which have produced an agaric. After continued rain *Xylaria nigripes* grows from deserted termite nests. Other fungi which grow on combs removed from the nest include *Mucor, Thamnidium, Cephalosporium, Peziza.* As these are not found in the nest though some of them are capable of development under ground, it is probable that the termites 'weed out' foreign fungi from the cultivation of the comb. The comb material is probably sterilized by its passage through the alimentary canal. That the 'spheres' form the food of the termites is probable, as in the case of the leaf-cutting ants: neither case can be considered definitely proved. *Termes redemanni* and *T. obscuriceps* undoubtedly prefer fungi, or wood which has been attacked by fungi. Whether a difference in food causes the differentiation of termites into workers, soldiers, and sexed insects, is not decided. A Ceylon agaric, *Entoloma microcarpum,* possesses a mycelium composed of spheres of swollen cells: the details of these spheres resemble the parts of the termite spheres, but are not so highly developed. It is most probable that the 'spheres' in the termite comb and the 'Kohlrabihäufchen' of the leaf-cutting ants investigated by Mœller are parts of a normal mycelium, and that their shape is modified by the insects only in a very slight degree, if at all. The available evidence appears to show that the 'spheres' are part of the mycelium of the *Volvaria,* but it has not been possible to connect these forms experimentally." A review covering some other features of Petch's work has just been published by Harris in the American Naturalist (1907).

The foregoing accounts from several observers show that the fungus-growing termites differ from the Attiine ants in several important particulars. In the first place the termites use their own excrement as a substratum,

moulding it into the form of a sponge containing numerous habitable chambers and galleries. This substance is, of course, much harder and more compact than the comminuted leaves, etc., employed by the Attii. Second, the fungus grown on this substratum forms bromatia (the spherules or oïdial heads) of a very different type from those found in the gardens of the Attii. And third, the termites that are in the habit of growing fungi are not exclusively mycetophagous like the Attii, but subsist also and probably very largely on dead wood, twigs and leaves. If it be true as Holtermann and Doflein believe, that the termites are not instrumental in maintaining the purity of the fungus culture, we should have another striking difference, but it is quite conceivable that both in the termites and the ants some effluviæ emanating from the myriads of insect bodies may be responsible not only for the suppression of alien fungi but also for the aberrant growth of the food-plant.

I have already called attention to the fact that Holtermann cannot be said to have demonstrated that the *Agaricus rajap* is the fruiting form of the fungus which grows in the gardens as a mycelium with oïdial spherules. And Doflein's and Petch's observations are open to similar doubts. Not only is there no satisfactory proof that the termite fungus is a basidiomycete, but the same is true also of Mœller's statement that the South American *Attæ* cultivate the mycelium of a fungus (*Rozites gongylophora*) belonging to the same group. A careful perusal of Mœller's observations shows an important lacuna at this point. That his *Attæ* ate portions of the pileus and stem of the *Rozites* does not prove that it is the fruiting form belonging to the fungus they habitually cultivate and eat. Nor is Mœller on much surer ground when he assumes that the mycelia cultivated by different genera of Attii belong to different species of fungi, for it is very probable that the ants of one species would avoid fungus taken from the nest of another on account of the alien nest-aura. Certainly, to the human olfactories the fungus gardens of *Atta texana* have a very striking odor which is altogether lacking in the gardens of *Trachymyrmex*, and it would be strange if these differences did not affect the appetites of such sensitive insects as the ants. In my opinion, it is not improbable that the fungi cultivated both by the termites and ants may be more closely related to the moulds (Ascomycetes) than to the mushrooms (Basidiomycetes). Mœller does in fact, call attention to certain ascomycete peculiarities in the mycelium cultivated by *Acromyrmex discigera*. This is a matter, however, to be settled by the mycologist, and I merely call attention to it in this connection, because Mœller's somewhat guarded statements have assumed an unduly positive form in the writings of subsequent reviewers of his work.

2. *The Ambrosia Beetles.*

The beetles of the family Scolytidæ may be divided into two groups exhibiting very different ethological peculiarities: the bark-borers, which excavate and inhabit tubular galleries between the bark and the splint and eat the substance of the tree, and the wood-borers, or ambrosia beetles, which extend their galleries into the wood and subsist on delicate fungi growing on their walls. All Scolytidæ are of small size and dark color, with cylindrical bodies and short legs adapted to the shape and size of their galleries (Pl. LII, Figs. 62 and 63), but the mouth-parts differ in the two groups; the bark-beetles having strong maxillæ armed with 12–20 spine-like teeth in adaptation to their hard food, whereas the fungus-eating wood-borers have weak maxillæ with 30–40 flexuous bristles. Unlike the Attii and fungus-growing termites, the wood-borers are not confined to the tropics or to a single hemisphere, but are cosmopolitan in their distribution and well represented even in the north temperate zone. The species have been assigned to a number of genera (*Platypus, Gnathotrichus, Trypodendron, Xyleborus, Xyloterus, Corthylus* and *Pterocyclon* [*Monarthrum*]). As these insects are very destructive to wood, they are well known to economic entomologists, who have described their habits in journals or text-books devoted to forestry. The remarkable habits have therefore been little noticed by entomologists interested in general biological questions.

There has been considerable difference of opinion in regard to the feeding habits of the ambrosia beetles since the time of Schmidberger (1836) who believed that *Xyleborus dispar* Fabr. fed on the sap exuding into its burrows from the surrounding wood. The mother beetle was supposed to mould this sap into a coagulated, albuminoid mass and to feed it to her young. This substance Schmidberger called "ambrosia." Various conjectures concerning its nature were expressed by Ratzeburg (1839–1844), Altum (1872–1875), and Eichhoff (1881). In 1844 Hartig discovered a fungus in the galleries of *Xyleborus dispar* and described it as *Monilia candida.* Several years later (1872*a*, 1872*b*) he described similar conditions in *Xyloterus lineatus* Oliv., which lives only in conifers, and *X. domesticus* L., which is confined to deciduous trees. In 1895 Goethe published a good description and figure of the fungus of *X. dispar.* At about this time Hubbard took up the study of the North American ambrosia beetles and published most interesting accounts of their habits (1897*a*, 1897*b*). Hopkins, too, who has given special attention to our Scolytidæ, has published a number of valuable observations (1898–1904*b*), and Hedgcock (1906) has made some important observations on the fungi. In the following para-

graphs I shall confine myself to an account of the investigations of these three authors.

The ambrosia beetles resemble the ants and termites and differ from other Coleoptera in living in societies and in caring for and feeding their larvæ. The arrangement of the galleries, which have walls stained dark by the fungus, differs in different species. Those of *Xyleborus celsus* Eichh., living in the hickory, are shown in Pl. LII, Fig. 64, taken from Hopkins (1904). The galleries ramify into the sapwood from a single entrance gallery that opens on the bark. These perforations do not necessarily kill the tree, but they spoil the wood for many commercial purposes. When made in young growing trees they may be overgrown by succeeding layers of wood. Hopkins (1903) has given an interesting account of this condition in trees infested with the Columbian timber-beetle (*Corthylus columbianus* Hopkins). This beetle which is responsible for losses to the lumber interests of North America "amounting to millions of dollars, attacks the sap-wood of the young, living, healthy tree, in which the adults excavate their brood galleries and deposit their eggs. These hatch and develop into beetles and emerge within one year. The next year the operation is repeated in another place in the same tree, and so on for hundreds of years, or as long as the tree lives, so that the galleries excavated in different years and periods occupy their respective positions in the heartwood and sapwood of the full-grown and old tree. Nearly all the damage by this insect, as affecting the best part of the trees, was done 50, 100, 200 or in some cases, as noted in an old tulip tree, over 400 years ago. The age of each gallery observed in the end of the log is easily determined by counting the number of annual layers of wood between the old healed-over entrance to the galleries and the bark. Within recent years, examples of the species which do this work have been exceedingly scarce; consequently but little evidence of its work can now be found in the sapwood and outer heartwood of living trees. Therefore there is no remedy for the old work and probably no need of trying to combat an insect which is apparently becoming extinct."

Hubbard's general account (1897*a*) of the fungus growing habits of the ambrosia beetles is worth quoting *in extenso*, as it is one of the most important of recent contributions to the study of insect ethology: "A small fragment of ambrosia taken from the gallery of any species of these timber beetles, if placed on a glass slide, with a drop of water or glycerine and examined with an objective of moderate power, is plainly seen to be a fungus. It will be found, however, that the different kinds of ambrosia fungi are connected with certain species of the beetles irrespective of the sort of timber in which the galleries are constructed. So far as we yet know the food of each species of ambrosia beetles is limited to a certain kind of ambrosia, and only the most closely related species have the same food fungus.

"Two principal types exist among the varied forms of these minute fungi: (1) Those with erect stems, having at the termination of the stems, or their branches swollen cells (conidia) [Pl. LII, Fig. 65]. (2) Those which form tangled chains of cells resembling the piled-up beads of a broken necklace. The erect or stylate forms are found among those species of the beetles whose larvæ live free in the galleries (*Platypus* and *Xyleborus*). The bead-like or moniliform kinds appear to be peculiar to the species whose larvæ are reared in separate cells or cradles (*Corthylus, Monarthrum,* etc.).

"All the growing parts of the fungus are extremely succulent and tender. The conidia especially are always pellucid, and glisten like drops of dew. When the plant is in active growth, conidia are produced in the greatest abundance, growing sometimes singly, at the end of short straight stems, sometimes in grape-like clusters among interlacing branches. At such periods the fungus appears upon the walls of the galleries like a coating of hoarfrost. The young larvæ nip off these tender tips as calves crop the heads of clover, but the older larvæ and the adult beetles eat the whole structure down to the base, from which it soon springs up afresh, appearing in little white tesselations upon the walls.

"The growth of ambrosia may in fact be compared to asparagus, which remains succulent and edible only when continually cropped, but if allowed to go to seed is no longer useful as food. In like manner the ambrosia fungus must be constantly kept in fresh growth, otherwise it ripens; its cells burst and discharge the protoplasmic granules which they contain in myriads, and the entire plant disappears as if overwhelmed by a ferment.

"Various disturbances of the conditions necessary to its growth are apt to promote the ripening of the fungus, and this is a danger to which every colony of ambrosia beetles is exposed. If through any casualty the natural increase of a populous colony is checked, there results at once an overproduction of the ambrosia. It accumulates, ripens, and discharges its spores, choking the galleries and often suffocating the remaining inhabitants in their own food material. The same results may sometimes be brought about by closing the outlets of the galleries through the bark, or by spraying into them kerosene or some other noxious liquid. The inmates of the colony are thereby thrown into a panic, the beetles rush hither and thither through the galleries, trampling upon and crushing young larvæ and eggs, breaking down the delicate lining of ambrosia on the walls of the brood chambers and puddling it into a kind of a slush, which is pushed along and accumulated in the passage ways, completely stopping them in places. The breaking down of the food fungus follows and in a few days the galleries are filled with a paste-like mass of granules or spores, or with threads of mycelium, in which the living insects are suffocated and destroyed.

"The ambrosia does not make its appearance by accident or at random in the galleries of the beetles. Its origin is entirely under the control of the insect. It is started by the mother beetle upon a carefully packed bed or layer of chips, sometimes near the entrance, in the bark, but generally at the end of a branch gallery in the wood. In some species the ambrosia is grown only in certain brood chambers of peculiar construction. In others it is propagated in beds, near the cradles of the larvæ. The excrement of the larvæ is used in some and probably in all species to form new beds or layers for the propagation of the fungus.

"It is not alone, however, the excreta of the living beetles or their young that is required for the development of ambrosia; there must be present a certain amount of moisture or sap, and the sap in most species must be in a condition of fermentation. Certain ambrosia beetles, as for example the species of *Corthylus*, seem not to need fermentation in the propagation of their fungus; their galleries are constructed in the sap-wood of vigorous plants. The great majority of the species, however, attack the wood of such trees only as are moribund; in which the natural circulation of the sap has ceased, and fermentation has begun. Some of the number are also able to produce their food fungus in wood which is saturated with a vinous or alcoholic ferment, and they attack wine and ale casks, perforating the staves with their galleries and causing serious loss by leakage.

"The precarious conditions under which their food is produced limit the life of a colony of ambrosia eaters in most cases to a single generation.

"Under favorable conditions, and in large tree trunks, colonies may continue their excavations during two or three generations before the failure of the sap or change in its condition puts an end to their existence and forces the adult beetles to seek new quarters.

"When their galleries are disturbed and opened to daylight, the adult beetles generally fall to eating their ambrosia as rapidly as possible. Like other social insects they show their concern at the threatened loss of their most precious possession and try to save it, just as bees, when alarmed, fill themselves with honey.

"As its honey is to the bee, so to the ambrosia-feeding beetle its food fungus is the material the propagation and preservation of which is the chief concern of its life. Its solicitude concerning it is not surprising when one considers the herculean labors which it undergoes in the effort to produce it, the frequent failures, and the difficulties and uncertainties that at all times attend its preservation in the vegetative form, in which alone it can serve the insect as food."

The life-histories of the ambrosia beetles described and copiously illustrated by Hubbard suggest a wide range of habits within the group. The

genus *Platypus*, though best represented in the tropics, contains several of the largest and most destructive species in the United States. "They are powerful excavators, generally selecting the trunks of large trees and driving their galleries deep into the heart-wood. They do not attack healthy trees but are attracted only by the fermenting of the sap of dying or very badly injured trees. The death rattle is not more ominous of dissolution in animals than the presence of these beetles in standing timber. . . . The female is frequently accompanied by several males and as they are savage fighters, fierce sexual contests take place, as a result of which the galleries are often strewn with the fragments of the vanquished. The projecting spines at the end of the wing-cases are very effective weapons in these fights. With their aid a beetle attacked in the rear can make a good defense and frequently by a lucky stroke is able to dislocate the outstretched neck of his enemy. The females produce from 100 to 200 elongate-oval pearl-white eggs, which they deposit, in clusters of 10 or 12, loosely in the galleries. The young require five or six weeks for their development. They wander about in the passages and feed in company upon the ambrosia which grows here and there upon the walls. . . . The older larvæ assist in excavating the galleries, but they do not eat or swallow the wood. The larvæ of all ages are surprisingly alert, active and intelligent. They exhibit curiosity equally with the adults, or show evident regard for the eggs and very tender young, which are scattered at random about the passages, and might easily be destroyed by them in their movements. If thrown into a panic the young larvæ scurry away with an undulatory movement of their bodies, but the older larvæ will frequently stop at the nearest intersecting passage and show fight to cover their retreat." The ambrosia of *P. compositus* Say consists of hemispherical conidia growing in clusters on branching stems. The long continued growth of this fungus blackens the walls of the older galleries.

Xyleborus saxeseni Ratzb., instead of producing ramifying galleries, excavates in hardwood trees (oak, hickory, beech, maple) a flat, leaf-shaped brood chamber connected with the surface of the bark by one or a few tubular galleries. The chamber "stands vertically on edge, parallel with the grain of the wood. The space between the walls is not much greater than the thickness of the bodies of the adult beetles. The larvæ of all ages are able to cling to the vertical walls, and to progress over them by an adaptation of the end of the body which aids them in progression. The entire surfaces of the walls in the brood chamber are plastered over with ambrosia fungus. It consists of short erect stems, terminating in spherical conidia. The freshly grown fungus is as colorless as crystal, but it is usually more or less stained with greenish yellow, and sometimes resembles a coating

of sublimed sulphur. The brood chamber is packed at times with eggs, larvæ, pupæ and adults in all stages of maturity. The larvæ aid in extending the brood chamber. They swallow the wood which they remove with their jaws, and in passing through their bodies it becomes stained a mustard-yellow color. Great quantities of this excrement are ejected from the openings of the colony, but a portion is retained and plastered upon the walls, where it serves as a bed upon which there springs up a new crop of the food fungus. In populous colonies it is not unusual to find the remains of individuals which have died packed away in a deep recess of the brood chamber and carefully inclosed with a wall of chips." Hubbard found one of these catacombs containing "the multilated bodies of a dozen or more larvæ and immature imagoes, together with the fragments of a predatory beetle, *Colydium lineola* Say." In a short branch gallery of the same chamber he also found the lifeless body of the mother of the colony carefully sealed up by the surviving insects.

In the species of *Pterocyclon, Xyloberus* and *Gnathotrichus* the young are reared in cradles, or short diverticula of the main galleries, and fed by the mother beetles. In species of *Ptercyclon* (*mali* Fitch and *fasciatum* Say) "the sexes are alike, and the males assist the females in forming new colonies. The young are raised in separate pits or cradles which they never leave until they reach the adult stage. The galleries, constructed by the mature female beetles, extend rather deeply into the wood, with their branches mostly in a horizontal plane. The mother beetle deposits her eggs singly in circular pits which she excavates in the gallery in two opposite series, parallel with the grain of the wood. The eggs are loosely packed in the pits with chips and material taken from the fungus bed which she has previously prepared in the vicinity and upon which the ambrosia has begun to grow. The young larvæ, as soon as they hatch out, eat the fungus from these chips and eject the refuse from their cradles. At first they lie curled up in the pit made by the mother, but as they grow larger, with their own jaws they deepen their cradles, until, at full growth, they slightly exceed the length of the larvæ when fully extended. The larvæ swallow the wood which they excavate, but do not digest it. It passes through the intestines unchanged in cellular texture, but cemented by the excrement into pellets and stained a yellowish color. The pellets of excrement are not allowed by the larvæ to accumulate in their cradles, but are frequently ejected by them and are removed and cast out of the mouth of the borings by the mother beetle. A portion of the excrement is evidently utilized to form the fungus bed. The mother beetle is constantly in attendance upon her young during the period of their development, and guards them with jealous care. The mouth of each cradle is closed with a plug of the food fungus, and as

fast as this is consumed it is renewed with fresh material. The larvæ from time to time perforate this plug and clean out their cells, pushing out the pellets of excrement through the opening. This débris is promptly removed by the mother and the opening again sealed with ambrosia. The young transform to perfect beetles before leaving their cradles and emerging into the galleries." The ambrosia of *Pterocyclon* "is moniliform and resembles a mass of pearly beads. In its incipient stages a formative stem is seen, which has short joints that become globular conidia and break apart. Short chains of cells, sometimes showing branches, may often be separated from the mass. The base of the fungus mass is stained with a tinge of green, but the stain on the wood is almost black."

In *Xyloterus retusus* Lec., which lives in the broad-toothed aspen (*Populus grandidentata*) of the northern States, and is the largest of our ambrosia beetles, still other peculiarities are observable. "Several pairs of the beetle unite in colonies having a single entrance, but each family occupies its own quarters, consisting of one or two branch galleries. The galleries do not penetrate deeply into the heart-wood. Each female attends her own brood, which are raised in cradles extending upward and downward at right angles to the main passage-way. She feeds the young with a yellowish ambrosia grown in beds in the neighborhood of the cradles. The mouth of each cradle is constantly kept filled with a plug of the food fungus. The ambrosia consists of oval cells which form upright sticks resembling some forms of styliform ambrosia, but they do not branch and are capable of being broken up into beadlike masses without losing their vegetative powers. Although the color of the fungus is yellowish, the galleries are stained intensely black."

The foregoing account of the ambrosia beetles suggests a number of intricate and important problems for future investigation. That these insects have developed unusually advanced social habits for Coleoptera is certain. It is also evident that the fungi which they cultivate are not basidiomycetes but chromatogenic or wood-staining ascomycetes. Hedgcock (1906) who has recently studied these fungi, describes a number of species referable to the genera *Ceratostomella* (wood-bluing), *Graphium, Hormodendron, Hormiscium* (wood blackening and wood-browning), *Penicillium* and *Fusarium* (wood-reddening). Cultures of one of the species (*Graphium ambrosiigerum* Hedgc.) were made from material taken from the burrows of ambrosia beetles in the wood of *Pinus arizonica* Eng. The mycelium was seen to develop stromata with heads, and both primary and secondary conidia, but the author records no observations on the relations of the beetle to the fungus or the modifications produced in the food plant when in the presence of the insect. From some investigations now in progress at the Royal School of Forestry at Tharandt, Saxony, and communicated to

me by Professors K. Escherich and F. W. Neger it would seem that in the case of the ambrosia beetle *Trypodendron lineatus* the fungus is found only in the mycelial and conidial stages when the insects are present, but that when these have been removed stromata with globular or flattened heads, similar to those figured by Hedgcock for *Graphium atrovirens* and *ambrosiigerum*, are produced on the walls of the galleries.

The constant association of certain species of ambrosia beetles with certain species of fungi, irrespective of the kind of wood on which they grow, indicates that the mother beetles must be instrumental in transferring the plant from colony to colony and from tree to tree in some manner analogous to the fungus transfer of the *Atta* queen when establishing her formicary. Hedgcock seems to have found evidence of some such transference of *Ceratostomella* conidia. He says: "These are readily disseminated by the wind and are probably carried by insects which penetrate the wood and bark of trees, like most of the ambrosia and bark beetles. At the stage in which the conidia form a mucilaginous mass, they adhere readily to any insect that may pass over them. In the laboratory a number of species of mites which feed on fungi carried spores on their bodies from colony to colony in an agar plate to a sterile portion of the surface of the medium and started new colonies of the fungus. Bark beetles were placed in a dish with the conidial stage of *Ceratostomella* and after allowing them to remain a short time were transferred to sterile agar plates which were inoculated with spores from the insects. It is probable that some species of insects feed on the conidial stage of *Ceratostomella*, especially one or more species of ambrosia beetles and a number of mites infesting their channels in the wood; but proof is yet lacking on this point. The constant occurrence of this fungus in the channels of a number of wood boring beetles indicates that the conidia or the ascospores must be carried in some manner by these insects."

Interesting as are the observations on the fungicolous ants, termites and beetles collated in the preceding pages, we must admit that they are still fragmentary and leave many fundamental questions unanswered. It will be seen that our knowledge of the fungi cultivated by all three of these insect groups is very unsatisfactory and that many more investigations must be undertaken before we shall be able to determine the precise taxonomic affinities of the plants and to estimate the extent of the modifications induced in their growth by the symbiotic insects. Equally fragmentary is our knowledge of the phylogenetic origin and development of the fungus-growing habit. Indeed, this problem in the termites and ambrosia beetles has scarcely been recognized a yet. The views that have been entertained in regard to the phylogeny of the Attii and their habits are perhaps, of sufficient interest to command attention till further observations are forthcoming.

3. *The Phylogeny of the Attii and of the Fungus-growing Habit.*

The Attii belong to a complex of Myrmicine genera once grouped together as Cryptocerides on account of their superficial resemblance to the ants of the genus *Cryptocerus*. Forel in 1892 was the first to split up this artificial group. He divided the genera into four tribes, the first including the Attini, the second the Dacetonini, again divisible into three subgroups: *a*, *Strumigenys*, *Orectognathus*, *Epitritus* and possibly *Hypopomyrmex*; *b*, *Daceton* and *Acanthognathus*, and *c*, *Rhopalothrix*, *Ceratobasis* and *Cataulacus*. To a third tribe he assigned *Meranoplus* and *Calyptomyrmex*, which were recognized as having affinities with the Tetramorii, and to a fourth tribe he assigned *Cryptocerus* and *Procryptocerus*. In 1893 he said: "Taxonomy has proved to me that the Attini are intimately related to the Dacetonini (*Strumigenys*, etc.) and has led me to suppose that the Attini are of secondary derivation. This is all the more probable, because they are confined to the American continent, whereas the Dacetonini are distributed over the whole world, even to New Zealand."

Emery, writing in the same year (1893), expresses himself somewhat more explicitly. "If we separate from the *ensemble* of the ancient Cryptocerides, on the one hand *Cryptocerus* and *Procryptocerus* (group Cryptocerini), on the other hand *Cataulacus* (forming by itself a distinct group), and if furthermore, *Meranoplus* and *Calyptomyrmex* be attached to *Tetramorium* and its allies, all that remains of M. Forel's Attini may be divided into two groups according to the venation of the wings. In the genera *Atta*, *Sericomyrmex*, *Cyphomyrmex*, *Glyptomyrmex* [*Myrmicocrypta*], *Apterostigma*, the radial cell is closed and there is no trace of a discal cell nor of a recurrent nervure, the trunk of the cubital nervure being straight or feebly sinuous. In the genera *Rhopalothrix*, *Strumigenys* and *Epitritus* the radial cell is open; in the female *Rhopalothrix petiolata* Mayr I find a vestige of a recurrent nervure, and in the male *Strumigenys imitator* Mayr the trunk of the cubital vein is strongly arcuate behind at the base, indicating the point of insertion of a recurrent nervure that has disappeared. According to Smith's figures, *Daceton*, which has a discal cell, belongs to this latter group; probably the same is true of *Acanthognathus*, *Ceratobasis* and *Orectognathus*, whose wings are still unknown. The former of these two groups, which we may call the *Attini genuini* is exclusively American, whereas the latter, which may bear the name Dacetini, is represented in all the zoological regions except the Ethiopian. These two groups are, however, very closely allied, and the fossil genus *Hypopomyrmex*, which undoubtedly approaches the ancestors of *Strumigenys* very closely, has a discal and a closed radial cell. The closed radial cell is an archaic character and is found only in a

few Myrmicine genera, such as *Cryptocerus, Atopomyrmex, Myrmecina, Pheidologeton, Aëromyrma, Carebara, Lophomyrmex* and certain species of *Tetramorium.* In my opinion no great taxonomic importance is to be attached to this character; nevertheless its constant occurrence in the true Attini must be taken into consideration."

In a later paper (1895) Emery groups the genera above mentioned as follows:

Tribe Dacetii: *Daceton, Acanthognathus, Orectognathus, Strumigenys, Epitritus, Rhopalothrix, Ceratobasis.*

Tribe Attii: embracing besides the genera and subgenera enumerated in the introduction to this paper, *Wasmannia* and possibly also *Ochetomyrmex.*

Tribe Cryptocerii: *Procryptocerus* and *Cryptocerus.*

Tribe. Cataulacii: *Cataulacus.*

Emery is apparently of the opinion that the Attii are related to the Tetramorii through such intermediate genera as *Wasmannia* and *Ochetomyrmex,* whereas Forel is inclined to seek their origin among the Dacetonii through such a series of genera as *Cyphomyrmex, Rhopalothrix* and *Strumigenys.* Morphological considerations may be adduced in support of either of these contentions. The question then naturally arises as to whether there are in the Dacetonii or Tetramorii any ethological peculiarities which by further development could lead to the highly specialized fungus-growing habits of the Attii.

Forel (1902) regards *Cyphomyrmex* as the most primitive genus of Attii and believes that some of the species do not raise fungi, whereas the others make very imperfect gardens on insect excrement. These ants would thus be transitional in their habits to the Dacetonii, many of which also live in damp places in rotten wood, where fungi grow in abundance and where there is plenty of insect excrement that might gradually come to be employed as a substratum. In an earlier paper (1893) Forel quotes in support of his view an observation of H. Smith on the West Indian *Strumigenys smithi* Forel, a species which nests in rotten wood. Smith says that "the cavities in which these ants are found are *always* black inside, as if with some fungoid growth." Forel infers from this that some species of *Strumigenys* cultivate fungi. It seems to me, however, that his view evaporates into a mere hypothesis when the facts are more closely scrutinized. In the first place, there is no known species of *Cyphomyrmex,* nor in fact any Attiine ant, which does not cultivate fungi. I have shown in the third part of the present paper that statements to the contrary in regard to *C. rimosus* are false and due to superficial observations. In the second place, there is not a particle of evidence to prove that the Dacetonii cultivate fungi. The

species discovered by Smith may have been nesting in the abandoned fungus-stained galleries of ambrosia beetles, or the dark color of the walls may have been due to other causes. I may say also that in no colonies of the various species of *Strumigenys* which I have found in the United States and West Indies were there any traces of fungi. These ants live in rather small communities under stones or in rotten wood and feed on insects. Many of our species live as thief ants, after the manner of *Solenopsis molesta* Say, in the nests of larger ants. *Rhopalothrix* seems to have similar habits, to judge from some field notes accompanying a colony of an undescribed species taken, with all its larvæ and pupæ, under a stone in Jamaica.

Forel's view, however, contains an interesting suggestion, for the nature of the substratum on which the fungi are grown may be supposed to throw some light on the origin of the habit under discussion. In all the fungicolous insects there is an unmistakable tendency to employ vegetable substances that have passed through the alimentary tract of insects. This is the case in all fungus-growing termites, and in the ambrosia beetles. Among the Attii, as I have shown, this tendency is apparent in nearly all the species that have been closely observed. Though most pronounced in the lower genera and subgenera (*Cyphomyrmex, Apterostigma, Mycocepurus, Trachymyrmex*), it is not wholly lost even in the leaf-cutting *Attæ*, and the method employed by the *Atta* queens in manuring their incipient fungus-gardens suggests that the food plant may have been originally grown on fecal substances. It is quite possible, however, that in the Attii this habit is secondary and that it was preceded phylogenetically by culture on some other substance since generally abandoned as less suited to the purpose. This leads us to a consideration of another view on the origin of the fungus-growing habit.

Von Ihering (1894) advances the following opinion: "We know quite a number of ants, like the species of *Pheidole, Pogonomyrmex* and furthermore species of *Aphænogaster* and even of *Lasius*, which carry in grain and seeds to be stored as food. Such grain carried in while still unripe, would necessarily mould and the ants feeding upon it would eat portions of the fungus. In doing this they might easily come to prefer the fungi to the seeds. If *Atta lundi* still garners grass seeds and in even greater than the natural proportion to the grass blades, this can only be regarded as a custom which has survived from a previous cultural stage." Thus von Ihering would explain the origin of fungus cultivation and the supervention of the leaf-cutting habit.

This view, like Forel's, is, of course, purely hypothetical. There are, however, a few facts which indicate that the Attii may have developed from grain-storing species allied to the Tetramorii (*Meranoplus* and *Tetramorium*) as Emery has suggested. That certain harvesting species form nests and

have many peculiarities of behavior similar to those of the smaller Attii is shown by Santschi's observations on *Oxyopomyrmex santschii* Forel of the Tunisian deserts. In a letter to Forel, Santschi states that the nests of this ant are "so characteristic that when one has once seen one of them, nothing is easier than to find others. I am surprised to find that they have not attracted the attention of other observers. Especially remarkable is the tiny crater, which has the form of a cone, hardly more than 4–5 cm. in diameter and 2.5–3 cm. high. The circumference of its funnel-shaped top is 3–4 cm. across and its margin is always perfectly circular and entire, except in nests in process of construction, where it is at first semilunar like the very small nests of *Messor arenarius*. At the bottom of the funnel the small entrance is found, 1–2 mm. in diameter, just large enough to permit one of the workers to pass. A single nest has rarely two entrances and two cones. A single perpendicular gallery descends below the surface. A first chamber is found at a depth of 2–3 cm. It is horizontal, attaining a length of 5 cm., a breadth of 1 cm. and a height of 5 cm. In this first chamber the pupæ are kept for the purpose of enjoying the warmth and here I have found a number of workers and winged females. Thence the gallery continues to descend to a depth of 15–20 cm. and finally opens into two or three chambers of the same dimensions as the first. These contain pupæ and an ample provision of very small seeds. This ant is therefore granivorous. I surprised a few of the workers entering the nest with seeds in their mandibles. They go out foraging singly and not in files like *Messor* and other genera. They are very slow in their movements and are very apt to stop motionless at the least alarm. Day or night one or two of the workers may be seen on the outer surface of the crater scarcely moving unless molested, but when disturbed they hurriedly retreat into the nest to spread the alarm. Their habits are rather nocturnal. If a light is brought near the nest when a worker is on the point of leaving it with a grain of sand she hurriedly backs into the entrance and there stops, closing it perfectly with her burden. If the observer remains very quiet, she eventually comes forth and deposits her load on the slope of the crater. There are scarcely more than thirty individuals in a nest."

Although *Oxyopomyrmex* has no close taxonomic relations with the Attii or Tetramorii, but rather with members of the complex genus *Stenamma*, it closely resembles *Trachymyrmex turrifex* and *Mycetosoritis hartmanni* in the small size of its colonies, the slowness of its movements and the structure of its nests. These resemblances are in all probability, due to convergent development. Nevertheless, species with habits like *Oxyopomyrmex* might conceivably become fungicolous by some such substitution of instincts as that suggested by von Ihering. So many assumptions, however, would

have to be made in order to account for the delicate and intricate adaptations shown by existing Attii in the cultivation of their fungi, that further speculation seems idle till we are in possession of a greater body of careful observavations.

Less hypothetical and worthier of confidence are the views of Forel and von Ihering concerning phylogenetic development within the narrow confines of the Attiine tribe itself. But here, too, we must proceed with caution. The ants of the genera and subgenera *Cyphomyrmex, Myrmicocrypta, Sericomyrmex, Apterostigma, Mycocepurus* and *Mycetosoritis* on the one hand, are obviously primitive, for they form small colonies and have monomorphic workers and proportionally small males and females. On the other hand, *Atta* s. str. would seem to be the most recent and highly specialized genus of the tribe, because the colonies are very populous, the workers are polymorphic with marked division of labor, and the males and females are very large. Between these two groups, *Trachymyrmex, Acromyrmex* and *Mœllerius* occupy an intermediate position. Mœller and subsequent writers have been inclined to find a parallel development in the instincts, but this is not so clear as the morphological sequence and relations of the various genera and subgenera, for we find *Atta* s. str. and *Acromyrmex* building gardens on the floors of their chambers like *Cyphomyrmex*, whereas *Apterostigma* has highly specialized gardens, suspended and enveloped in a mycelial web not known to occur in any other Attii. Moreover, at least one species of *Cyphomyrmex* (*rimosus*) and a species of *Atta* s. lat. (*Mycocepurus smithi*) cultivate a very different fungus from that known to occur in the nests of any other species; *C. wheeleri* does not, at least as a rule, use caterpillar excrement as a substratum but only small plant slivers; *Mycetosoritis* specializes to the extent of using only the anthers of flowers, and *Sericomyrmex opacus* has a predilection for fruit pulp. All of these species are therefore aberrant in their habits, though belonging to primitive genera. Mœller has certainly overestimated the primitive nature of the treatment bestowed on the fungi in the nests of *Cyphomyrmex* as a group, and although the bromatia of the *Apterostigma* gardens may be of a generalized type, this genus is in many other respects more highly specialized than *Atta* s. str.

Granting the cogency of these considerations, it still remains true that the Attii in general present a series of increasingly specialized forms as we pass from the species of *Cyphomyrmex* through the subgenera *Mycetosoritis, Trachymyrmex, Acromyrmex* and *Mœllerius* to *Atta* s. str. in which we see the culmination of a wonderful progress in adaptation. These insects in the fierce struggle for existence, everywhere apparent in the tropics, have developed a complex of instinctive activities which enables them to draw upon an ever-present, inexhaustible food-supply through utilizing the foliage of plants

as a substratum for the cultivation of edible fungi. No wonder therefore, that, having emancipated themselves from the precarious diet of other ants, which subsist on insects, the sweet exudations of plants and the excrement of phytophthorous Rhynchota, the Attii have become the dominant invertebrates of tropical America!

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EXPLANATION OF THE PLATES.

Plate XLIX.

Fig. 1.— *Cyphomyrmex rimosus* Spinola var. *comalensis* var. nov. Worker.
Fig. 2.— *Cyphomyrmex wheeleri* Forel. Worker.
Fig. 3.— *Atta* (*Trachymyrmex*) *turrifex* Wheeler. Worker.
Fig. 4.— *Atta* (*Trachymyrmex*) *septentrionalis* McCook. Worker.
Fig. 5.— *Atta* (*Mœllerius*) *versicolor* Pergande. Worker.
Fig. 6.— *Atta* (*Mycetosoritis*) *hartmanni* sp. nov. Worker.
Fig. 7.— The same in profile.
Fig. 8.— *A.* (*M.*) *hartmanni* sp. nov. Male.
Fig. 9.— *Atta* (*Trachymyrmex*) *arizonensis* sp. nov. Deälated female in profile.
Fig. 10.— Head of same from above.
Fig. 11.— *Atta texana* Buckley. Soldier.
Fig. 12.— Thorax of same in profile.
Fig. 13.— *Atta texana*. Media.
Fig. 14.— *Atta texana*. Minima.

Plate L.

Fig. 15.— *Atta* (*Mycocepurus*) *smithi* Forel. Worker.
Fig. 16.— Same in profile.
Fig. 17.— *Sericomyrmex opacus* Mayr. Worker.
Fig. 18.— *Myrmicocrypta brittoni* sp. nov. Worker.
Fig. 19.— Same in profile.
Fig. 20.— *Apterostigma pilosum* Mayr. Worker.
Fig. 21. *Atta sexdens* L. Brazil. Hypopygium of male.
Fig. 22.— *Atta cephalotes* L. Panama. Hypopygium of male.
Fig. 23.— *Atta insularis* Guérin. Cuba. Hypopygium of male.
Fig. 24.— *Atta texana* Buckley. Texas. Hypopygium of male.
Fig. 25.— *Atta mexicana* F. Smith. Mexico. Hypopygium of male.
Fig. 26.— *Atta* (*Mœllerius*) *versicolor* Pergande. Male. Genitalia from above.
Fig. 27.— Unusual triple nest-entrance of *Trachymyrmex turrifex*.
Fig. 28.— Unusual double nest-entrance of *Mycetosoritis hartmanni*.
Fig. 29.— Bromatia of fungus (*Tyridiomyces formicarum* gen. et sp. nov.), cultivated and eaten by *Cyphomyrmex rimosus* and its various subspecies and varieties.

Plate LI.

Fig. 30.— Nest diagram of *Mycetosoritis hartmanni* (Nest X of the table on p. 763), showing four chambers, the connecting galleries, and the pendent fungus gardens.
Fig. 31.— Nest diagram of *M. hartmanni* (Nest T of the table on p. 763), with three chambers all containing fungus gardens.
Fig. 32.— Nest diagram of *M. hartmanni* (Nest U of the table on p. 763), with three chambers.

Fig. 33.— Nest diagram of *Trachymyrmex turrifex* (Nest L of the diagram on p. 756), with five well-developed chambers and pendent fungus gardens in all but the first.

Fig. 34.— Nest diagram of *T. turrifex* (Nest N of the table on p. 756), with four chambers, the lowermost small, recently excavated, and with an incipient garden suspended from rootlets.

Fig. 35.— Nest diagram of *T. turrifex* (Nest O of the table on p. 756), with four well-developed chambers and flourishing gardens in three of them.

Fig. 36.— Nest diagram of *T. turrifex* (Nest P of the table on p. 756), with five chambers and poorly developed fungus gardens in three of them. This nest shows very clearly the suspension of the substratum from the rootlets hanging into or traversing the chambers.

Fig. 37.— Nest diagram of *Trachymyrmex septentrionalis* var. *obscurior* (Nest C of the table on p. 749), consisting of only two chambers, both containing pendent fungus gardens.

Fig. 38.— Nest diagram of *T. obscurior* (Nest D of the table on p. 749), consisting of three chambers two of which open directly into each other. The mound of sand is shown in the typical position in front of the oblique entrance gallery. The first chamber contains exhausted substratum ready to be carried out of the nest.

Plate LII.

Fig. 39.— Nest diagram of *Trachymyrmex obscurior* (Nest I of the table on p. 749), of the racemose type, with five chambers. Extending from the single chamber on the right is an unfinished gallery. All the chambers contain well-developed pendent gardens except the first, which is partially filled with exhausted substratum.

Fig. 40.— Nest diagram of *T. obscurior* (Nest J of the table on p. 749) of the racemose type, with seven chambers, six of which are of large size. Of the latter, five contain flourishing gardens but one (to the extreme right) seems to have been only recently excavated by the ants. The crater of this nest was best developed behind the entrance.

Fig. 41.— Nest diagram of *T. obscurior* (Nest G of the table on p. 749) of the racemose and horizontally spreading type, with four chambers. The first chamber, in which the mother queen established her colony, had been subsequently enlarged by the workers.

Fig. 42.— Nest diagram of *T. obscurior* (Nest H of the table on p. 749) of the racemose type, with four chambers. As in the preceding, the first chamber had been enlarged by the workers, the lowermost was apparently in process of excavation.

Fig. 43.— Cells composing the bromatia of *Tyridiomyces formicarum*, the peculiar fungus grown by *Cyphomyrmex rimosus*.

Fig. 44.— Cells composing the bromatia of the same or an allied species of *Tyridiomyces* grown by *Mycocepurus smithi* var. *borinquenensis*.

Plate LIII.

Fig. 45.— Nest diagram of *Trachymyrmex obscurior* (Nest F of the table on p. 749), resembling the nests of *T. turrifex*, with five chambers.

Fig. 46.— Nest diagram of *Trachymyrmex turrifex* (Nest R of the table on p. 756) in pure sand, showing the elongation of the galleries.

Fig. 46a.— Deeper portion of the same nest with incipient gardens on the rootlets traversing the two lower chambers.

Fig. 47.— *Attaphila fungicola* Wheeler. Male. From nest of *Atta texana.*

Fig. 48.— *A. fungicola.* Female; dorsal view.

Fig. 49.— Same, ventral view.

Fig. 50.— *Attaphila bergi* Bolivar. Male, from nest of *Acromyrmyx lundi.* (After Bolivar.)

Fig. 51.— *A. bergi,* Female. (After Bolivar.)

Fig. 52.— Head of same. (After Bolivar.)

Fig. 53.— Hypopygium of same. (After Bolivar.)

Fig. 54.— *A. bergi.*— Hypopygium of male. (After Bolivar.)

Fig. 55.— Fungus garden of *Termes bellicosus* Smeathm. (After Smeathman.)

Fig. 56.— Bromatia of same more highly magnified. (After Smeathman.)

Fig. 57.— Portion of the fungus garden of a Malayan *Termes,* showing spherical bromatia of *Agaricus rajap* Holtermann. (After Karawaiew.) Natural size.

Fig. 58.— Bromatium from the fungus garden of an African Termite, *Termes vulgaris* Havil. (After Trägårdh.)

Fig. 59.— Portion of same crushed under a cover-glass and more highly magnified, to show the component cells. (After Trägårdh.)

Fig. 60.— A fungus garden of the African *Eutermes heterodon* Sjöst. $\frac{2}{3}$ natural size. (After Sjöstedt.)

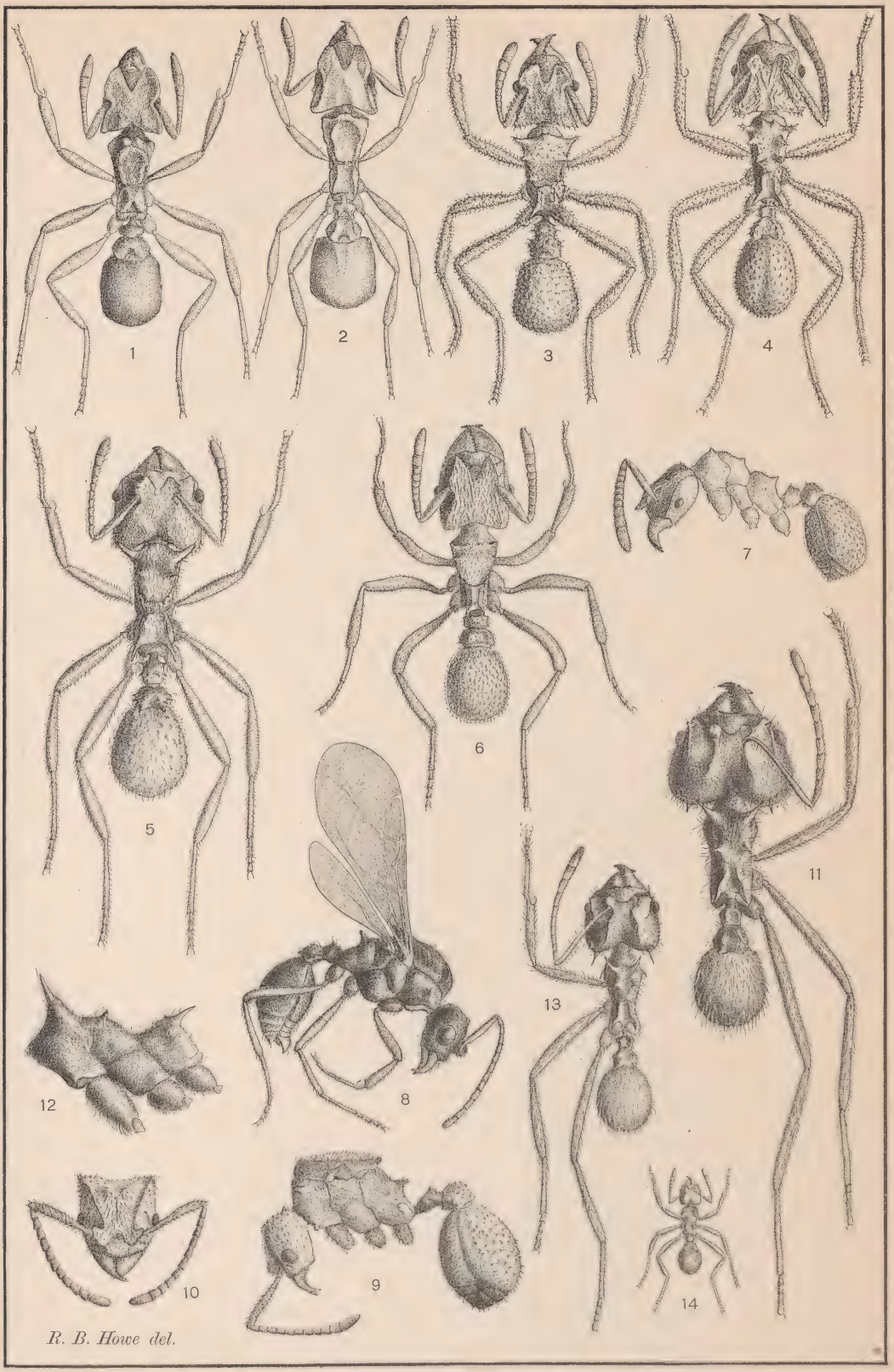
Fig. 61.— Section of same. (After Sjöstedt.)

Fig. 62.— Ambrosia beetle (*Xyleborus celsus* Eichh.) of the hickory. Female, enlarged. (After Hubbard.)

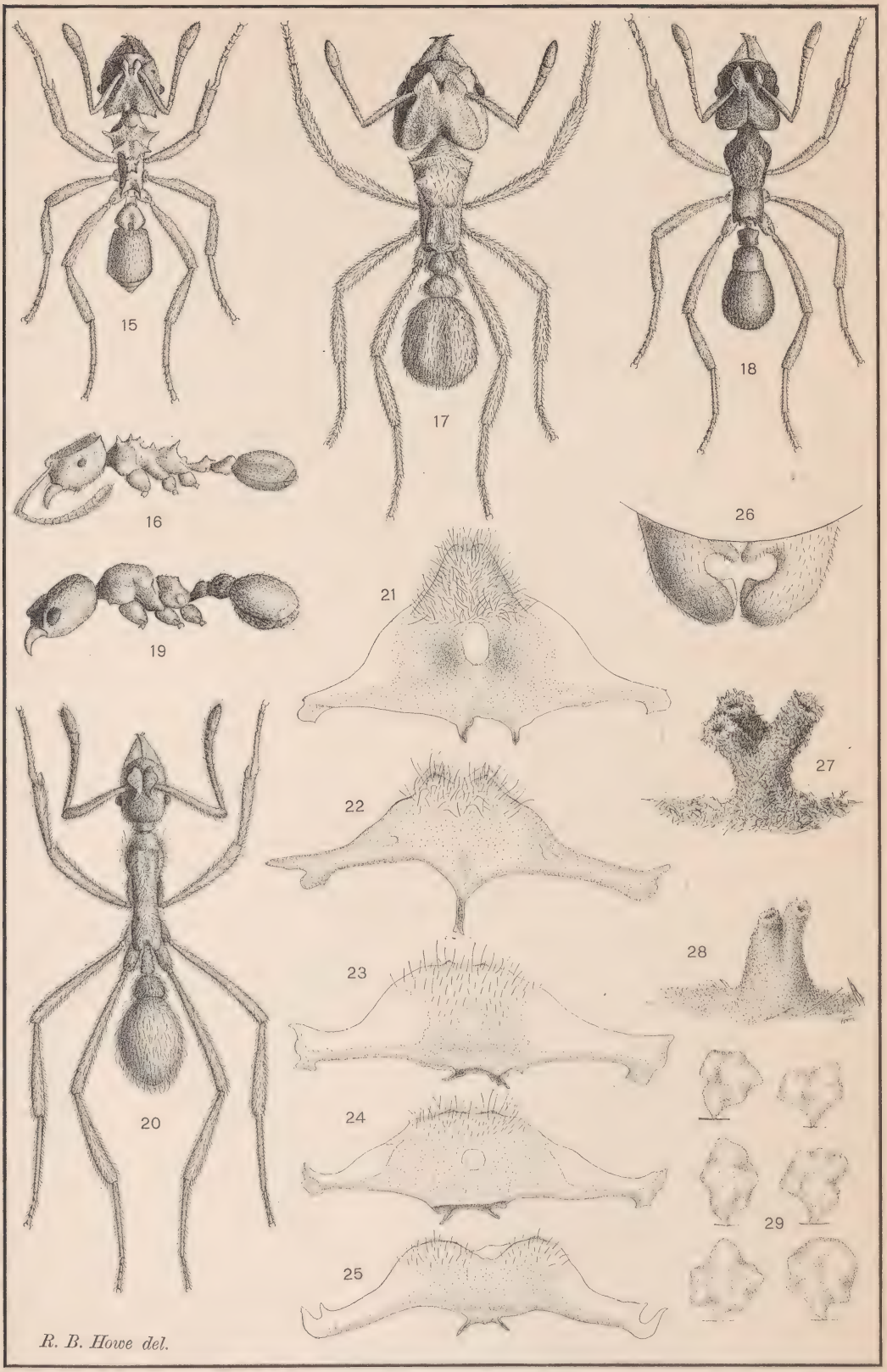
Fig. 63.— *X. celsus,* Male. (After Hubbard.)

Fig. 64.— Piece of hickory showing burrows of *X. celsus* in the sapwood. (After Hopkins.)

Fig. 65.— "Ambrosia" or fungus grown by *X. celsus* enlarged. On the right a few of the filaments more highly magnified.



Fungus-growing Ants of North America.



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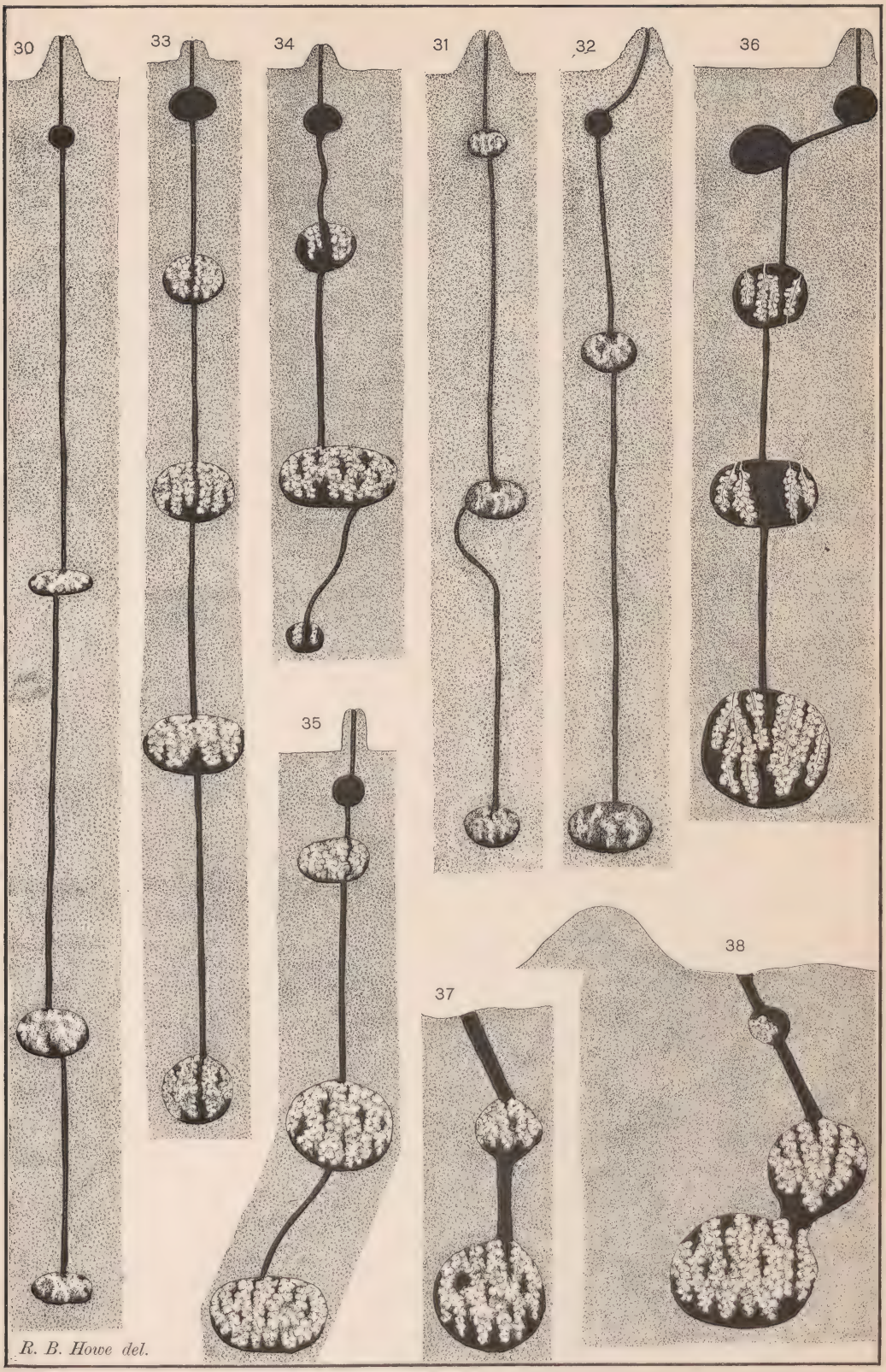

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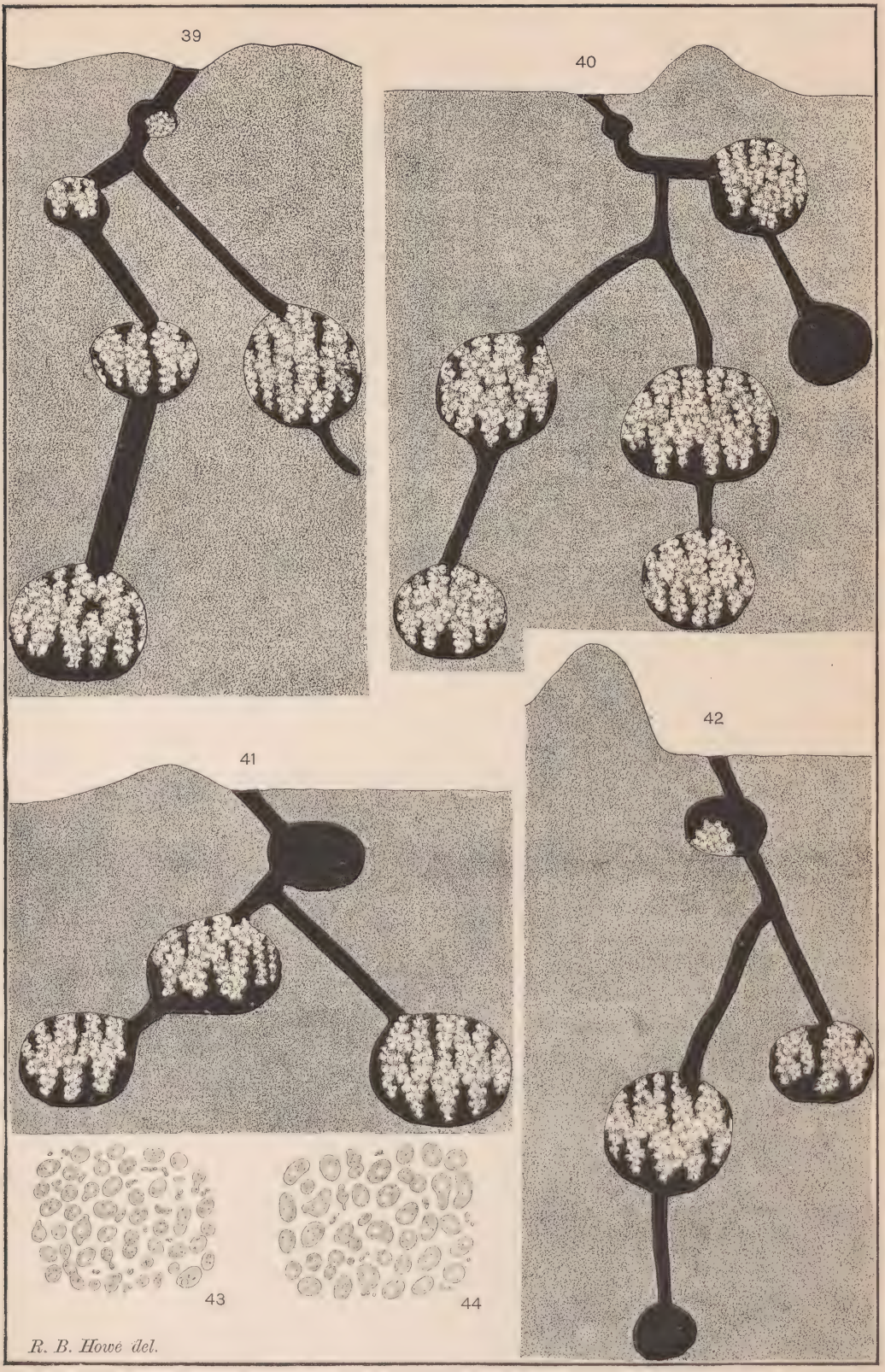

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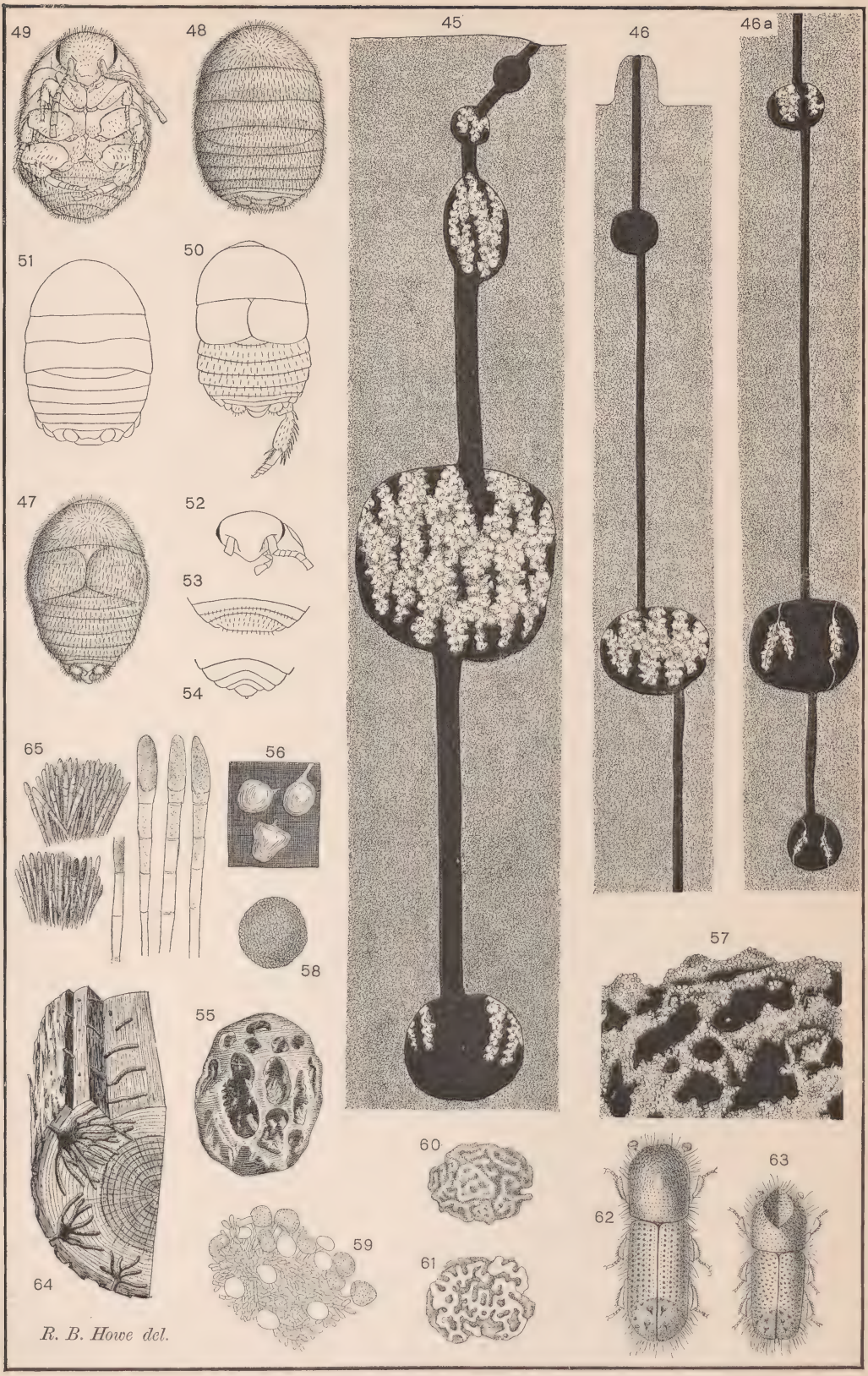


FUNGUS-GROWING ANTS OF NORTH AMERICA.

56.9.73 m (1182: 78.6)

Article XXXII.—NEW MERYCOIDODONTS FROM THE MIOCENE OF MONTANA.

By Earl Douglass.

The collections which were made in Montana in 1902, by the party from the American Museum of Natural History under Dr. W. D. Matthew, contain some Merycoidodonts which are of much interest in connection with the study of this subfamily of Artiodactyls. Through the kindness and courtesy of Prof. H. F. Osborn and Dr. W. D. Matthew, the best of this material has been sent to me for study. Two of the specimens, which I have named *Mesoreodon longiceps* and *Ticholeptus brachymelis*, are represented by almost complete skulls with large portions of the skeletons. They were found in beds from which no fossils had previously been obtained. Another specimen which came from the Upper Miocene beds of the Lower Madison Valley, is the skull of *Pronomotherium altiramum* (Douglass). The type of this species is a right ramus of a mandible containing the molar and premolar teeth. It was originally assigned by Douglass to the genus *Merycochœrus*.

The two first specimens above mentioned were found in beds of fine buff-colored sands, which may contain some clay, on the east side of the North Boulder River about six miles above where it empties into the Jefferson River. The beds are quite definitely stratified or banded. They dip to the westward toward the river and away from the ridge of Palæozoic limestone which forms the eastern boundary of the valley and the western face of the low mountain ridge which separates this valley from the larger one near the head of the Missouri River. A small area, apparently of White River strata (a remnant left by erosion) intervenes horizontally between the Miocene deposits and the Palæozoic limestone. In outcrops of the Miocene a little farther south part of a mandible of a *Cosoryx* was found. On the west side of the river, in deposits similar in appearance, Mr. Douglass obtained portions of a skull and mandible of a small Camel. In another locality but in a nodular stratum many fragments of teeth and bones of small and large Camels were obtained, some of which belonged to a large species of *Procamelus*. Associated with these were remains of turtles, one nearly complete shell of which Dr. O. P. Hay referred to the species *Testudo hollandi* Hay.[1] The type of this species was found by O. A. Peterson

[1] No. 1570 Carnegie Museum Catalogue of Vertebrate Fossils. See Annals of the Carnegie Museum, Vol. IV., No. 1, p. 19.

in the Loup Fork beds near the Running Water River in Nebraska. In another place to the westward and more distant from the river, part of the skull of a *Neohipparion,* very much like *N. isonesum,* was found. Still farther to the westward and at a higher level are beds that contain coarser sand and are more evidently of stream origin. They are much like the later Miocene deposits of the Lower Madison Valley. From these the mandible of *Neohipparion* was obtained. The above named specimens are in the Carnegie Museum. It is impossible to say how nearly of the same age are the beds on the opposite sides of the river, for the various deposits of Oligocene and Miocene times, in western Montana, are so mixed on account of the carving out and refilling of the valleys, good exposures are so isolated, and the lithological characters occasionally so deceptive, that one cannot always be sure as to the horizon without obtaining characteristic fossils. In some places, too, the fossils are nearly all Agriochœrids and of different species from those found elsewhere; while in other places no specimens of this family are obtained. I assign these beds provisionally to the Middle Miocene.

Detailed descriptions and records of variations are of little interest unless they give some evidence as to the vital economy of the animal, and its relations to its surroundings or to kindred forms. I give below some of the portions of the osteological anatomy of the Merycoidodonts which have been found to be especially subject to variations, show how some of these appear to be correlated, and give some conjecture as to their meaning.

Some of the parts subject to variations are the following: (1) The posterior basal portion of the skull, (*a*) tympanic and mastoid portions of the temporal, (*b*) exoccipitals; (2) the skull as a whole — varying proportions of length, height, and width; (3) upper antero-posterior contour of skull — nearly straight or arched; (4) the mandible, (*a*) horizontal ramus relatively short, low or high (none have slender mandibles), (*b*) angle medium or large; (5) sagittal crest low, or absent, light, or heavy; (6) malar (always quite heavy) deep, or relatively shallow.

Some of the following modifications might be considered progressive in their nature as they occur in nearly all the later forms, while other characteristics are possessed by only a portion of the members of the family: (1) Increase in size; (2) teeth, especially molars, becoming more hypsodont; (3) teeth increasing in length and height backward so that the molar is longer than the premolar series; (4) zygomatic portions of the squamosals enlarged or otherwise changed; (5) premaxillaries coössified; (6) limbs and feet shortened or lengthened, becoming heavier or more slender; (7) some slight shifting of the bones of the manus; (8) nasals shortened; (9) angle between basifacial and basicranial axis increased; (10) upper portion of

ascending ramus of the mandible changed; (11) palatines produced posteriorly; (12) modifications of the skull, especially the anterior portion, which in some cases was undoubtedly accompanied by lengthening and other changes in the upper lip and nose.

It is important to endeavor to ascertain how these different modifications are correlated. (1) Most of the specimens which have a heavy malar have a large angle to the mandible. This implies a great development of the superficial portion of the masseter muscle; (2) there is some evidence, perhaps, but not so much, of a similar relation between the portions of the skull and of the mandible to which the temporal muscle is attached; (3) shortening of the skull is usually accompanied by deepening of the mandible, lengthening of the molar as compared with the premolar series, and by heightening of the teeth. It is sometimes accompanied by shortening of the nasals and broadening of the skull; (4) the lengthening of the skull is not necessarily correlated with the lengthening of the limbs.

It is difficult to see of what use was the development of extremely large zygomatic arches like those in some species of *Promerycochœrus* unless they were used for defense or had weapons of defense attached to them.

The peculiarities in the structure of the Agriochœridæ which makes it appear probable that they usually inhabited woods, streams, marshes, and thickets, and that they subsisted principally on coarse foods such as leaves, twigs, rushes, coarse grasses, etc., are: (*a*) attachments for strong masticatory muscles; (*b*) long and probably large bodies for the accommodation of large viscera; (*c*) short legs and feet not adapted to life in the open country; (*d*) phalangigrade gait with spreading toes enabling them to walk on soft ground and probably to swim with facility in the water; (*e*) no apparent correlation between long heads and long necks or limbs, as is usually the case with animals that subsist on short grasses; (*f*) a long upper lip or proboscis, in some species, which would undoubtedly be useful in procuring leaves and coarse grasses.

Mesoreodon longiceps sp. nov.

Type No. 9732, American Museum of Natural History. A nearly complete skull with the mandible, the cervical, lumbar, and sacral vertebræ, portions of most of the dorsal vertebræ, a scapula, a pelvis, a femur, a tibia, a fibula, a nearly complete hind limb including the foot, several other foot-bones, and many fragments. From Middle or Upper Miocene deposits on the east side of the North Boulder Valley near Cold Spring post-office in Jefferson County, Montana. Collected by Albert Thomson of the American Museum party under Dr. W. D. Matthew in July, 1902.

The characters which distinguish this species from the type of *Mesoreodon* are numerous, and in some respects considerable in degree. The following are some of the distinguishing peculiarities:

Skull long, especially the posterior portion; brain-case large and full; nasals and frontals arching; sagittal crest sessile, represented by a small low ridge; median pillar of occiput broad; space between paroccipital and postglenoid processes unusually large; palate produced considerably posterior to last molar; teeth but slightly hypsodont.

As the skull is more or less peculiar in most of its details it merits a quite full description. It is long in proportion to its height. This lengthening is principally posterior to the face, especially posterior to the glenoid articular surfaces. The length of the skull is almost twice the width. The upper contour is not quite straight as there is an arching of the anterior portion of the nasals, a depression of the posterior portion, an arching of the posterior portion of the frontals and the anterior portion of the parietal, while posterior to this convexity, the lowness of the sagittal crest forms a depression.

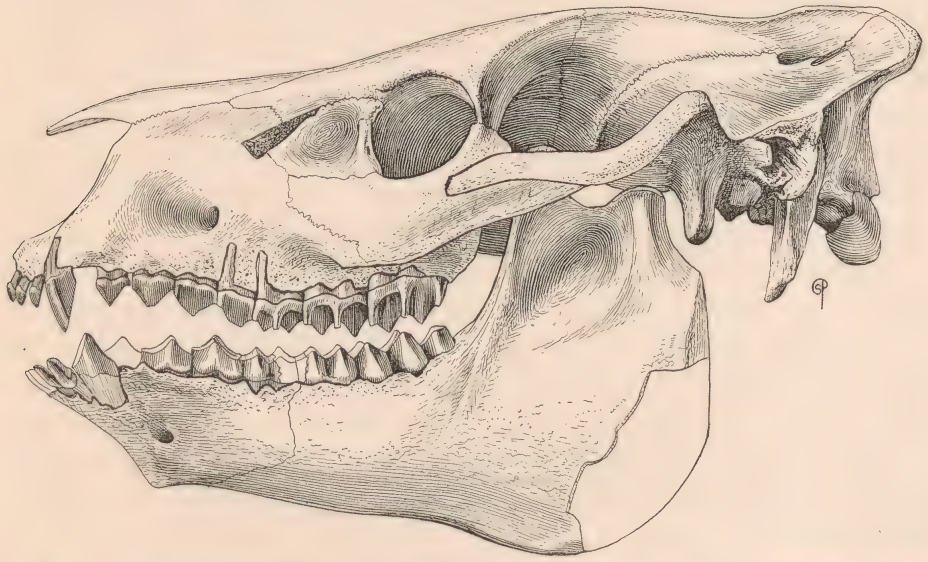


Fig. 1. *Mesoreodon longiceps*, side view of skull and jaws, × ½. Type specimen, Amer. Mus. No. 9732.

The premaxillaries are only slightly, if at all, coössified. The nasals do not extend as far forward as do the premaxillaries. They have slightly truncate or rounded tips, are convex antero-posteriorly and transversely at their broadest portions which are just posterior to the opening of the anterior nares, and their posterior ends are rounded. The frontals are mostly convex, though there is a depression just behind the nasals. The fronto-parietal suture is a considerable distance anterior to where the supratemporal ridges unite. The sagittal crest is represented by a low sessile narrow ridge which becomes a little higher just anterior to the occipital crest. Its backward extension continues as a very low ridge over the upper Y-shaped surface of the occipital crest, and in the median line beneath the posterior overhanging

portion of this crest between its lateral wings forms a high sharp rugose ridge. The pillar of the occiput is broad, slightly concave above and broadly convex below. It is bounded laterally by small ridges which extend downward from the lambdoid crest. External to the broad pillar are large deep concavities, or openings into the

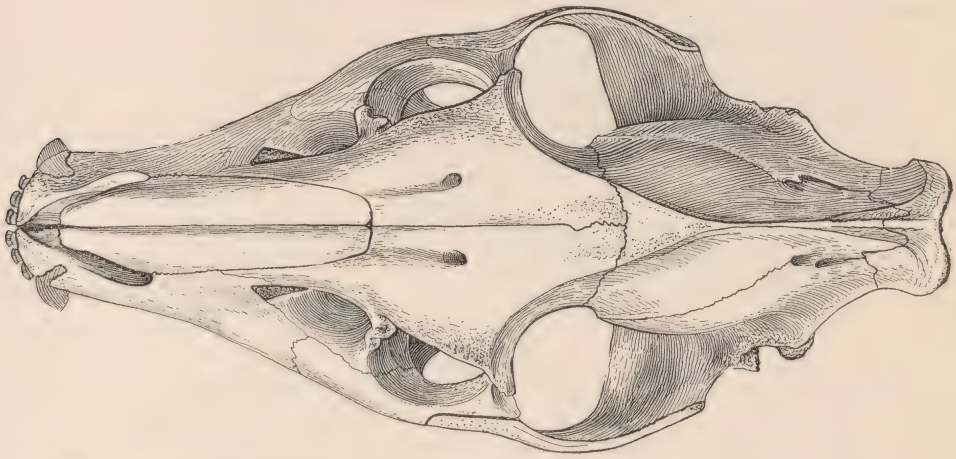


Fig. 2. *Mesoreodon longiceps*, superior view of skull, × ½. Type specimen, No. 9732.

brain case. Above and external to these are the high, thin, overhanging ridges or plates of the temporal bone. These ridges branch off from the lambdoid crests at the same places as the ridges previously described which are internal to the cavities. They are deflected downward on the outer portions of the mastoid processes which project considerably external to the exoccipitals. The occipital condyles

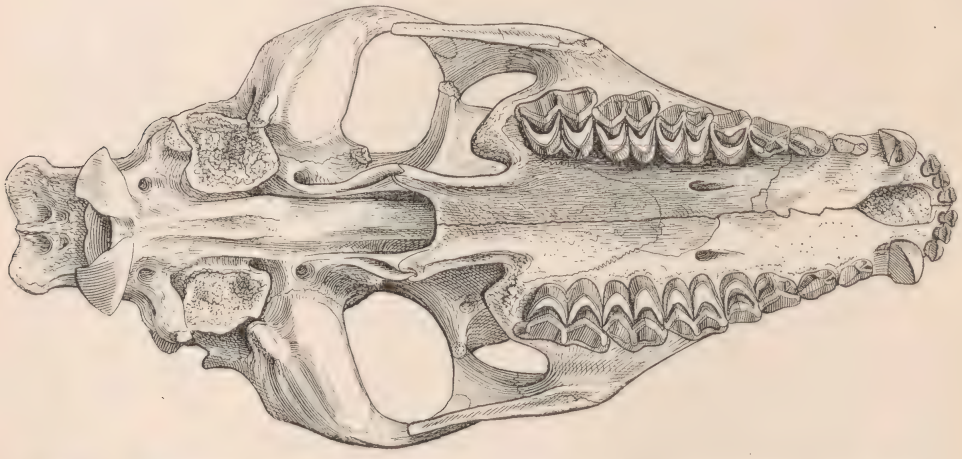


Fig. 3. *Mesoreodon longiceps*, inferior view of skull, × ½. Type specimen, No. 9732.

and foramen magnum are broad. The lower surface of the basioccipital is quite broad just anterior to the foramen magnum, but between the tympanic bullæ it suddenly contracts. Immediately in front of this on the median basal portion of the skull are two parallel longitudinal ridges instead of one. Anterior to these ridges

the basisphenoid is directed upward forming an angle with the basioccipital. The paroccipital processes are prismatic and are placed behind the tympanic bullæ, the lateral expansion of their bases being behind the external auditory meatus and the mastoid process. Their antero-posterior and transverse diameters behind the bullæ are nearly equal. Below this they are laterally compressed and slightly bent inward. The tympanic bullæ were large but the lower portions are not preserved. The opening of the external auditory meatus is just anterior to the mastoid process, but it sends a heavy wing forward to the base of the postglenoid process as in some species, at least, of *Eporeodon* of the Lower John Day beds. The postglenoid processes are unusually slender being narrow transversely. They are concave posteriorly on account of the broad channels which extend downward from the large post-glenoid foramen. The pterygoids are thickened below, thin above, concave on the outside, and convex on the inside. The pterygoid plates of the palatine, to which the pterygoids are attached on the inner surfaces, are concave postero-internally while the pterygoids are concave postero-externally so that the two form an oblong trough-like depression. The palatines extend backward in a trough-shaped extension 2.5 cm. behind the last molar. The infraorbital foramen opens above the posterior portion of $p^{\frac{3}{}}$ and the anterior portion of $p^{\frac{4}{}}$. There is an oblong triangular vacuity on the face surrounded by the maxillary, frontal, and lachrymal bones. The latter bone is large and the lachrymal pit is rather deep. The orbit is small and the malar quite deep. The zygomatic portion of the squamosal is slender in front, it reaches forward much beneath the orbit and the posterior angle is not high or heavy.

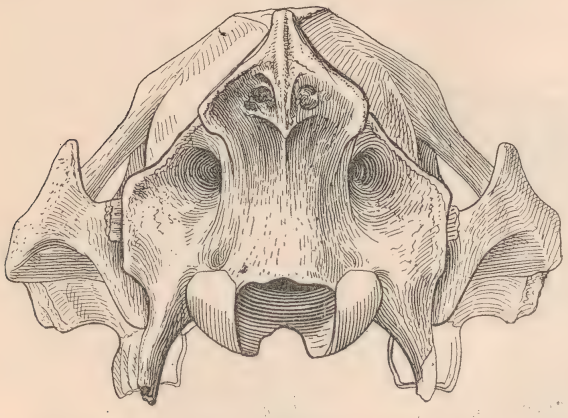


Fig. 4. *Mesoreodon longiceps*, occipital view of skull, × ½. Type specimen, No. 9732.

The horizontal ramus of the mandible increases in depth backward and the angle is large. The ascending ramus is broad antero-posteriorly, the coronoid process thin, and the masseteric fossa shallow.

The teeth are brachy-hypsodont or brachyodont with a tendency to become hypsodont. The incisors are not large. The canines have a vertical groove on the inner side. Premolars one to three in both jaws increase regularly in size backward and in the development of the ridges and depressions. The

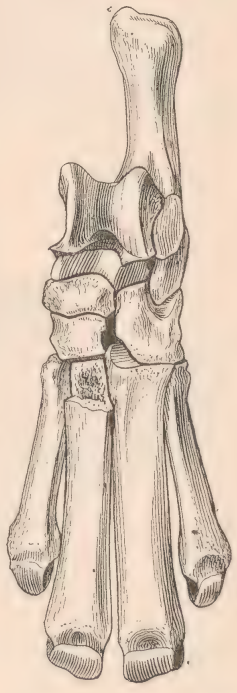


Fig. 5. *Mesoreodon longiceps*, hind foot, × ½. Type specimen, No. 9732.

molars also increase regularly in length and width. The molar series is slightly longer than the premolar series.

Judging from Scott's description of *Mesoreodon chelonyx* some of the bones of the present species show small differences in some of the details, but a comparison of the bones themselves is necessary to ascertain the exact amount of this difference. Judging by Scott's figure of the hind foot the metacarpals, especially the lateral ones (II and V), are more slender in *Mesoreodon chelonyx*.

Measurements.

	mm.
Length of skull, total	260
Length of skull, basal	247
Length of upper dental series	124
Length of skull posterior to dental series	124
Length of skull from posterior of $m^{\frac{3}{}}$ to anterior of post-glenoid process	64
Length of skull behind anterior portion of post-glenoid process	60
Width of skull, greatest	129
Width of posterior pillar of occiput	28
Height of skull above posterior base of $m^{\frac{3}{}}$	72
Length of upper premolar series	45
Length of upper molar series	56
Length of lower premolar series	49
Length of lower molar series	59
Depth of mandible under middle of $m^{\frac{3}{}}$	41
Length of metatarsal IV	73
Width of shaft of metatarsal IV, middle	12

Proportion of hight of skull to length = 72 : 260 = 27.7 : 100.
Proportion of width to length = 129 : 260 = 45.7 : 100.
Length of upper premolar to molar series = 80 : 100 = $\frac{4}{5}$ nearly.
Length of lower premolar to molar series = 83 : 100.
Proportion of width of metatarsal IV to length = 12 : 73 = 16.4 : 100.

Ticholeptus brachymelis sp. nov.

Type: No. 9731 American Museum of Natural History. A nearly complete skull with the mandible, the cervical and lumbar vertebræ, nine or ten dorsal vertebræ part of which are incomplete, and the greater portions of the fore limbs. Found in the same beds as *Mesoreodon longiceps*, on the east side of the North Boulder Valley opposite Cold Spring post-office. Collected by Albert Thomson of the American Museum party under Dr. W. D. Matthew in 1902.

Skull high in proportion to length. Greatest height to greatest length, 157 mm.: 257 mm. = 61: 100 or approximately $\frac{3}{5}$. Forehead only moderately broad; upper antero-posterior contour of skull nearly straight; sagittal crest short and not high;

orbit small; zygomatic arches deep under the orbit, ascending posteriorly; squamosal portion of arch not heavy; nasals shortened; horizontal ramus of mandible moderately deep, uniform in height from p $\frac{}{3}$ to m $\frac{}{3}$; premolar teeth not long or high; molars moderately hypsodont; proportion of length of upper premolar to molar series = 48 mm.: 60 mm. = 80 : 100 = $\frac{4}{5}$; lower molar to premolar series = 49 mm.: 64 mm. = 76.5 : 100; limbs and feet short.

The premaxillaries are coössified for a distance of 12 cm. The upper portion of the anterior narial opening is large and broadly rounded, the borders only moderately steep. The narials are abbreviated. The infraorbital foramen opens above the anterior portion of p $\frac{4}{}$. The malomaxillary ridge is heavy and the lachrymal pit deep. The malar is deep beneath the orbits and ascends backward. The squamosal portion of the zygomatic arch is heavy. The forehead is not extremely broad, neither is the occiput. The exoccipitals and the paroccipital processes are moderately expanded laterally. The internal portions of the latter, behind the tympanic

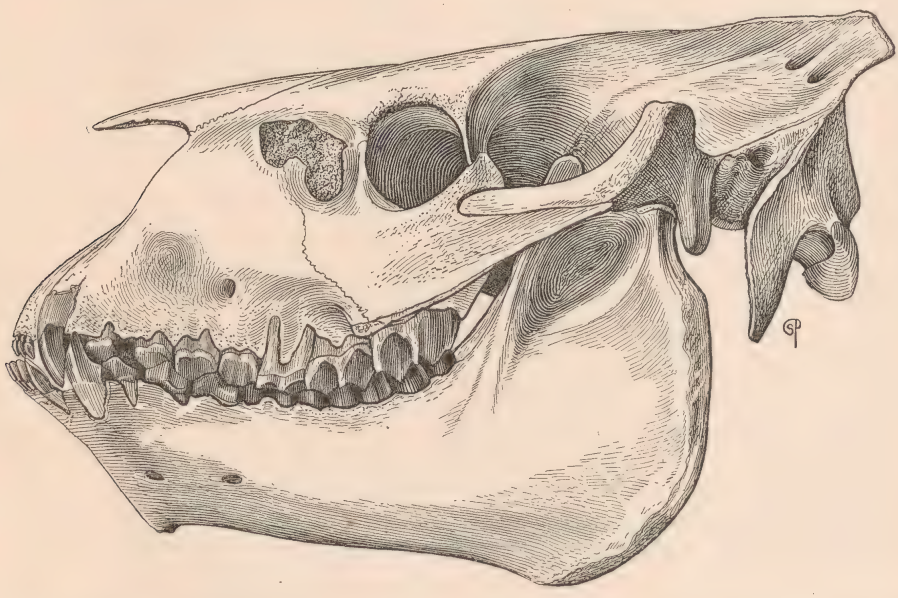


Fig. 6. *Ticholeptus brachymelis*, side view of skull and jaws, × ½. Type specimen Amer. Mus. No. 9731.

bullæ, are thickened antero-posteriorly. The bullæ are quite large. The external auditory meatus is a long, straight tube directed upward more than outward or backward. The angle of the mandible is large but does not extend very much below the lower border of the horizontal ramus. The masseteric fossa is deep.

From the type of the genus, *Ticholeptus zygomaticus* Cope, this species differs in the greater length of the skull in proportion to the height, in the more nearly straight upper contour of the skull, in the less thickened and rugose squamosal portion of the zygomatic arch, and in the less hypsodont teeth.

From *Ticholeptus breviceps* Douglass, from Divide Creek, Montana,

it differs in the following respects: Skull larger, longer, and proportionally narrower; brain-case proportionally smaller; paroccipital processes thicker antero-posteriorly; pillar of the occiput narrower and less flattened; occipital condyles less compressed antero-posteriorly; tympanic bullæ smaller; malars heavier and more ascending; form of squamosal processes of zygoma different; teeth less hypsodont; metopodials, and probably limbs, slightly more robust.

It is distinguished from *Ticholeptus bannackensis* Douglass from Grasshopper Creek above Bannack in Montana, by its smaller size, smaller premolar teeth, less, but more uniform, depth of the horizontal ramus of the mandible, and its shorter and proportionally heavier limbs and feet. Of the skull of *Ticholeptus bannackensis* only the anterior portion and the mandible are known.

Measurements.

	mm.
Width of skull, greatest, approximately	139
Depth of malar beneath orbit	34
Depth of mandible beneath $p\frac{}{4}$	38
Length of humerus not including greater tuberosity	164
Length of radius	134
Traverse diameter of radius, least	15
Length of metacarpal III	66.5
Width " " "	10.5

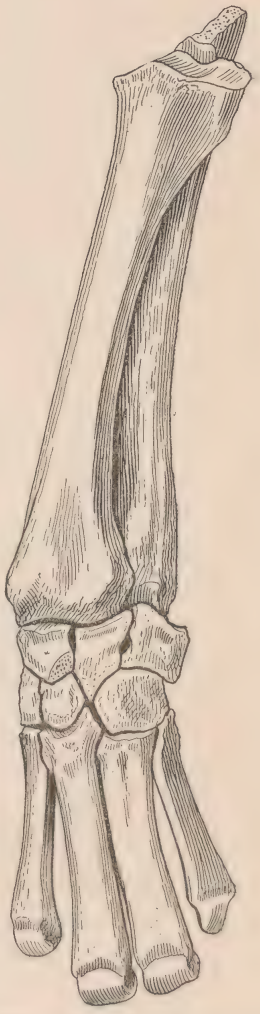


Fig. 7. *Ticholeptus brachymelis*, ulna radius and forefoot, front view, × ½. Type specimen No. 9731.

Pronomotherium altiramum (*Douglass*).

Merycochœrus altiramus Douglass, American Journal of Science, Vol. XI, January, 1901, pp. 73–75.

This species was founded on the greater portion of the right ramus of a mandible (Carnegie Museum Catalogue of Vertebrate Fossils, No. 759), found by Earl Douglass in a bed or pocket of sand at the base of the Loup Fork beds of the Lower Madison Valley in Montana, in 1895. In 1902 the expedition from the American Museum of Natural History obtained, in nearly the same place, the greater portion of a skull which I have no doubt belongs to the same individual. As this has been placed in my hands for study, it gives an opportunity to describe the principal characters of the

skull of this remarkable animal, and to compare it with the fine skull of its nearest known relative, *Pronomotherium laticeps*, in the Carnegie Museum.

When the mandible which was used as the type was first described it was lying in a bed of plaster, the removal of which and the more accurate fitting of the fragments, has somewhat changed the contour of the border of the horizontal ramus from that represented in figure 1 in the original description, making it more nearly like the mandible of *Pronomotherium laticeps*.

The skull, which represents a young individual, is longer than that of *Pronomotherium laticeps* and is broad posteriorly. It is more or less distorted, and probably the posterior and upper portions are pushed slightly backward. The length of the dental series is greater than the length of the skull posterior to it. The palate is long and not so broad as in *Pronomotherium laticeps*. It is produced backward of the molars and has a peculiar form. It is concave between the last molars and a little posterior to them, and the borders are thick and rounded. In the middle of this concavity is a low median longitudinal ridge. Posterior to this concave area is an area that is convex antero-posteriorly and concave transversely, being bounded laterally by two antero-posteriorly flattened processes. I cannot

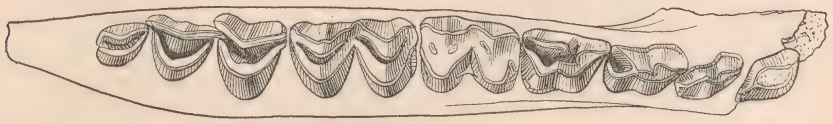


Fig. 8. *Pronomotherium altiramum*, superior view of lower jaw, $\times \frac{2}{3}$. Type specimen, Carnegie Mus. No. 759.

say how much of this portion of the skull belongs to the pterygoids and how much to the palatines. Behind the produced palate the pterygoid fossa is deep. The basi-occipito-sphenoid axis is very steep. The glenoid articular surfaces are large, slightly concave transversely, and decidedly convex antero-posteriorly. The postglenoid processes are broad transversely, thin antero-posteriorly, and quite high. The paroccipital processes are directed transversely. They are convex behind and flattened or slightly concave in front. The occipital condyles are broad transversely and narrow antero-posteriorly. The exoccipitals above the paroccipital processes are broad.

The malo-maxillary ridge extends to above $m\frac{1}{1}$. Above this the floor of the large facial concavity is nearly horizontal as in *Pronomotherium laticeps* but the posterior portion is probably somewhat crushed vertically. The malar beneath the orbit is moderately deep. The zygomatic portion of the squamosal is not deep, neither is its posterior angle high or heavy.

The forehead is flat and on its postero-external borders the temporal ridges are heavy, standing up like a wall.

The mandible is very deep. The chin is steep but it does not appear to have been so concave as in *P. laticeps*. Beneath $m_{\overline{2}}$ the horizontal ramus of the mandible becomes deeper and beneath $m_{\overline{3}}$ it descends still more abruptly.

Dentition.— The teeth are strongly hypsodont, increasingly so from the second premolar backward. Their antero-posterior diameters increase

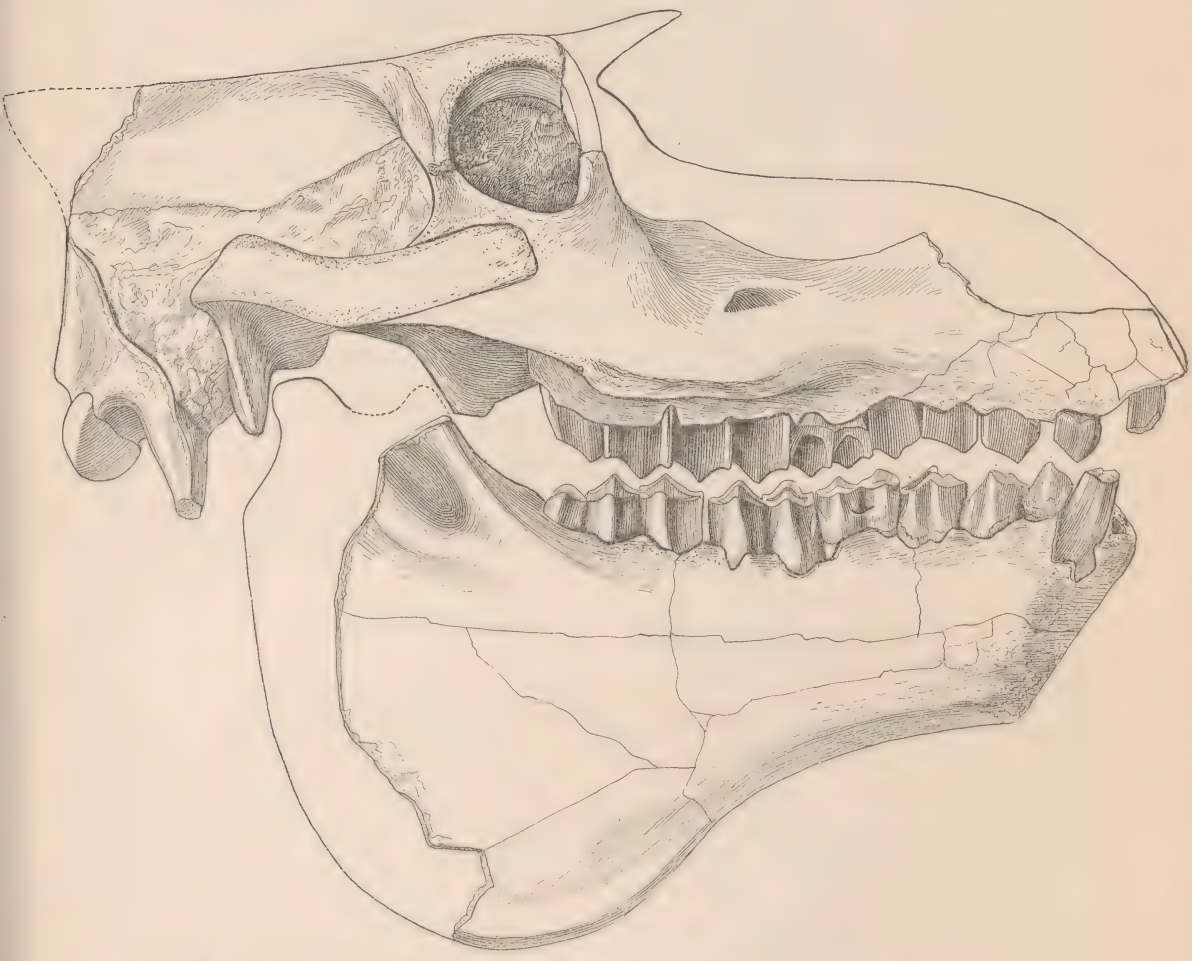


Fig. 9. *Pronomotherium altiramum*, side view of skull and jaws, × $\frac{2}{5}$. The lower jaw, Carnegie Mus. No. 759, is the original type of the species. The skull, American Mus. No. 9740, probably belongs to the same individual.

in the same order. The mandible and its dentition have been described in the paper cited at the beginning of this description.

Although the teeth are on the same general plan as those of other Merycoidodonts, the upper, even more than the lower ones, have some plainly distinguishing peculiarities.

The canine is not heavy. Its outer angle is sharp having an almost

knife-like edge, and on the inner surface there is a sharp and prominent slightly crescent-shaped ridge extending up and down on the tooth. The posterior surface of the tooth is flat, the antero-external one nearly so and the antero-inner one strongly convex. $P\frac{1}{-}$ is much smaller than the other premolars a is not dnset obliquely in the jaw. The antero-inner ridge, which usually separates the anterior and the anterio-inner facets in Merycoidodonts, in $p\frac{1}{-}$ and $p\frac{2}{-}$ of this specimen projects far forward so that part of the anterior fossa is seen in a side view of the skull. On $p\frac{3}{-}$ this fossa is broad and faces directly forward. The posterior portion of $p\frac{1}{-}$ is sharp (chisel-like), and slightly concave on the inner surface. The anterior ridge on $p\frac{2}{-}$ is inflected forward in such a way that the outer surface is concave and the inner one convex. The posterior cingular festoon is much larger than the anterior one. A portion of it is developed into a small subconical cusp which represents the deuterocone. The outer face of the tooth is slightly concave antero-posteriorly and convex vertically. $P\frac{3}{-}$ is wider than $p\frac{2}{-}$, especially the anterior portion. The deuterocone does not appear to be much larger. $P\frac{4}{-}$ has a strong inner cingulum. The inner crescent is concave vertically.

Measurements.

	mm
Length of skull, basal. Perhaps a little too long on account of distortion	305
Length of dental series not including incisors	175
Length of skull behind dental series	130
Width of muzzle at second premolars	77
Width of palate between last molars	55
Width of skull, greatest	220
Width of occipital condyles	85
Depth of malar beneath orbit	40
Height of mandible beneath $p\frac{}{4}$	58
Height of mandible beneath posterior of $m\frac{}{2}$	66
Height of mandible just behind $m\frac{}{3}$	128
Length of upper molar-premolar series	160
Length of upper premolar series	70
Length of upper molar series	90
Length of lower molar-premolar series	159
Length of lower premolar series	63
Length of lower molar series	96

Proportion of width to length of skull = 220 mm. : 305 mm. = 72 + : 100.

Upper premolar series to upper molar series = 77.7 : 100.

Lower premolar series to lower molar series = 65.6 : 100.

Length of upper pm. series = $m\frac{1}{-} + m\frac{2}{-}$ + nearly $\frac{1}{2}$ $m\frac{3}{-}$ = a little more than $m\frac{2}{-}$ + $m\frac{3}{-}$ = a little less than $m\frac{1}{-} + m\frac{3}{-}$.

Length of lower pm. series = $m\frac{}{1} + m\frac{}{2} + \frac{1}{2}$ anterior crescent of $m\frac{}{3}$ = less than $m\frac{}{1}$ and $m\frac{}{3}$.

Comparison of the skull of Pronomotherium altiramum with that of Pronomotherium laticeps.— The former is larger and but little broader; the palate is actually narrower; there is not so prominent an angle on the maxillary above and external to m^2 at the origin of the zygomatic arch; and the skull does not expand so abruptly here, there being more of a gradual widening posterior to the premolars. The specimen is a younger individual and the teeth not so much worn as in the type of the genus, yet it is evident that they were narrower, more hypsodont, and had sharper cusps and ridges.

A list of Agriochœrids from Montana is given below, arranged as nearly as can be done at present in their order of succession, though there is much doubt concerning the proper chronological arrangement of those listed as Middle and Lower Miocene. The list is a long one but nearly all are, so far as I have been able to examine and compare them, well characterized species, with one or two possible exceptions. It may be that *Merycoidodon macrorhinus* may turn out to be a very robust variety or individual of *Merycoidodon culbertsoni* and *Eucrotaphus helenæ* may be *Eucrotaphus bullatus* (Leidy). I have not seen the type of the latter, neither am I aware that it has been figured. I have also doubts as to the specific identity with the type of skulls that have been figured and described under that name. A number of other species — possibly a dozen — in the Carnegie Museum are represented by teeth, jaws, feet, and other parts of skeletons but they have not been named on account of the absence of good skulls.

UPPER MIOCENE.

Pronomotherium altiramum
Pronomotherium madisonius
Merycochœrus? compressidens } Lower Madison Valley.

Pronomotherium laticeps
Ticholeptus smithi
Poatrephes paludicola } Flint Creek near New Chicago.

Ticholeptus zygomaticus
Cyclopidius simus
Cyclopidius emydinus
Cyclopidius incisivus
Promerycochœrus montanus } Deep River Beds.

Ticholeptus breviceps, Divide Creek north of Melrose.

PERHAPS MIDDLE MIOCENE.

Ticholeptus bannackensis, Grasshopper Creek near Bannack.

Promerycochœrus? sp.
Ticholeptus brachymelis
Mesoreodon longiceps
} North Boulder River.

Merycoides cursor
Cyclopidius sp.
Promerycochœrus hatcheri
Promerycochœrus hollandi
Promerycochœrus grandis
} Canon Ferry east of Helena on the Missouri River.

LOWER MIOCENE OR UPPER OLIGOCENE.

Promerycochœrus minor, Hell Gate River near Drummond.
Eucrotaphus montanus, Stubbs Ferry northeast of Helena.

MIDDLE OLIGOCENE.

Eucrotaphus helenæ
Merycoidodon macrorhinus
Merycoidodon culbertsoni?
} Missouri Valley near Toston.

Eucrotaphus helenæ, Canon Ferry.

LOWER OLIGOCENE.

Bathygenys alpha
Agriochœrus? maximus
} Pipestone Creek.

Limnenetes anceps
Agriochœrus near antiquus
} McCarty's Mountain.

Limnenetes anceps
Limnenetes platyceps
Agriochœrus minimus
Trigenicus socialis
} Thompson's Creek near Three Forks.

55.1,77(78.6)

Article XXXIII.— THE HELL CREEK BEDS OF THE UPPER CRETACEOUS OF MONTANA:

THEIR RELATION TO CONTIGUOUS DEPOSITS, WITH FAUNAL AND FLORAL LISTS AND A DISCUSSION OF THEIR CORRELATION.

By Barnum Brown.

In the plains region of Montana east of the 108th meridian there is a series of Mesozoic strata overlain by fossil-bearing fresh-water deposits and lignite beds of unknown thickness. These beds are eroded into very rough badlands near the Missouri River north of Miles City.

The attention of Professor Osborn was first called to this locality by Dr. W. T. Hornaday, Director of the Bronx Zoölogical Garden, New York, who while hunting near the Missouri in 1901 discovered numbers of large bones in the bad lands. One of these bones, brought home for a paper weight, turned out to be the point of a horn of the large dinosaur *Triceratops*. In 1902 Professor Osborn sent the writer out to this region with such good results that the three succeeding years, 1903–6, were spent in the same general region. Thus a large collection of vertebrate, invertebrate and plant remains has been secured. Most of the exploration was in the Hell Creek region where continuous work has served to elucidate several seemingly complicated stratigraphical sections.

South of the Yellowstone.

Between Miles City and Dickinson along the Yellowstone and southeastward extending into Wyoming, and into North and South Dakota, are more or less continuous exposures composed of alternating sandstones and clays at base with several hundred feet of lignite and buff-colored shales toward the top. In most of these badlands remains of vertebrate animals are rare. The weathered fore limb of a *Triceratops* was identified by myself in the badlands near Glendive at an elevation of about 50 feet above the railroad track. Several other fragments of *Triceratops* and Trachodont dinosaurs were seen in this locality but not sufficiently preserved for specific determination.

South of Miles City, on Powder River, about twelve miles above Hockett, part of a *Triceratops* skeleton was found in dark shale near the level of the river. Several other fragmentary dinosaur bones were noted in this locality

but insufficient time was spent there to determine the relation of the different strata. Unconformably overlying the dinosaur-bearing clays west of Spring Creek there is a line of white cliffs, locally known as "Chalk Buttes," that extend into Wyoming. These beds are of Tertiary origin, probably Miocene, and resemble the Rosebud formation in lithological character. No fossils were found in them. However, in the First National Bank of Miles City there is a well preserved femur of a mastodon which is said to have been found in Powder River below the mouth of the Mizpah. It was undoubtedly washed down from this Tertiary bed, as all the surrounding strata at that point are older than the Fort Union.

Near Ekalaka the Field Columbian Museum expeditions have secured a collection of dinosaur remains which determine the dinosaur-bearing beds of that area as a continuation of those north of the river to be described later.

North of the Yellowstone.

Between the Yellowstone and the Missouri Rivers north of Miles City the surface of the country presents a rolling prairie, for the most part grassed over. Glacial drift is abundant over the region and near the Yellowstone, where it covers the ridges, is several feet in thickness. Near the Missouri it has been mostly eroded off and only the larger boulders remain.

On the divide between the two rivers there are few denuded areas; the largest exposure was found near the 21-mile road ranch on the stage road between Miles City and Jordan. Here the identified Fort Union has been eroded off, leaving the upper lignite clays. Another similar exposure was found on Thompson Creek. Both of these localities are barren of fossils where examined.

A few abrupt hills capped by sandstones stand out as monuments on the plains along the Little Dry at the road crossing and near Red Butte ranch. Near the Little Dry these sandstones contain unusually well preserved impressions of a rich flora that has been determined by Dr. F. H. Knowlton as of Fort Union age. The single specimen collected near Red Butte is a new species of *Cornus*, age uncertain. Lithologically these beds are of the same structure and are of about the same level, representing the middle and lower part of the Fort Union. Near the head of Crow Rock and Timber Creeks there is a range of light-colored higher hills, known as Sheep Mountains. They are probably of Tertiary origin.

In this longitude the Yellowstone is about 350 feet higher than the Missouri and its current is much swifter. It has cut through the identified Fort Union and a part of the lignite and sandstones which I believe belong

Fig. 1. Sketch map of western half of Dawson County, Montana. (X) indicate the location of important discoveries of vertebrate fossils. Scale 1 inch.

to the lignite series exposed on Hell Creek. No fossils were secured from this locality, however, and the determination is based on its lithological structure and position.

The Missouri River has long since cut through the Fort Union and underlying strata far into the Pierre. Erosion is rapid in these shales, consequently the banks of the lateral streams are steep. Most of the tributaries of the Missouri on the south side between the Musselshell and the Big Dry are short streams confined by steep cañons.

This area is unsurveyed and all published maps are inaccurate in name, course and size of most of the streams. A prominent landmark, such as Smoke Butte, is placed at least twenty miles from its true position on these maps. The accompanying sketch map (Fig. 1) was made from data secured during four years of field work in this region. Although inaccurate in many respects it approximately gives the true course and relation of streams.[1]

All the exposures examined on the tributaries of the Big Dry above the mouth of Woody Creek were found to be of Fort Union age; the country is open and for the most part grassed over. But as soon as the high divide bounding the short tributaries of the Missouri is crossed, the country takes on a more rugged character; the surface is eroded into badlands of wonderful beauty, the short deep cañons often presenting perpendicular walls from one to three hundred feet high with short lateral cañons that make the country almost impassable for riders. Many of these cañons, like Seven Blackfoot, are very narrow at the bottom. The torrents of water that flow down them in the spring freshets carry away the loose talus, leaving clean-cut, nearly vertical sections several hundred feet thick along streams not more than twenty miles in length, thus giving clean exposure of different strata. The following barometrical measurements were taken from one of these sections on Hell Creek by Dr. A. G. Leonard, State Geologist of North Dakota.

Fort Union	115 feet
Lignite beds	100 "
Hell Creek beds	310 "
Fox Hills	100 "
Pierre	150 "

These measurements agree with estimated thickness of sections on Crooked Creek and Gilbert Creek, with the exception of the Fox Hills, which on cañon sides frequently seems to be much thicker than they are, on account of slipping. Where I have seen clean sections of the Fox Hills

[1] Since this paper was prepared a very accurate map of this region has been published in the July issue of 'The Auk' (Vol. XXIV, 1907, facing p. 244) by Mr. E. S. Cameron.

on Crooked Creek and Seven Blackfoot it was never more than sixty feet in thickness.

Fort Pierre.

In this locality the river has cut into the Pierre shales to a depth of nearly two hundred feet. At the mouths of the tributaries and on some of the intervening points the overlying beds are eroded off leaving the shales weathered into low ridges or rounded hillocks of drab-colored gumbo. Where newly exposed they are composed of dark, almost black fissile shales and loosely joined ferruginous-stained clays. Gypsum crystals are numerous toward the top of the formation. Concretions of different sizes are found in nearly every stratum, though not in great numbers. They are always in distinctly bedded planes unlike those in the later fresh-water deposits. These concretions are calcareous and are usually traversed in all directions by cracks filled with amber-colored calcite crystals. Invertebrates are found in the shale but more often embedded in calcareous concretions.

On the west side of Hell Creek, five miles from its mouth and about one hundred feet below the Fox Hills, numbers of small elongate and lozenge-shaped concretions occur. They are calcareous but seldom show calcite reticulations. Where weathered out they are light gray in color and nearly always contain large invertebrates such as *Baculites ovatus* or *Inoceramus sagensis*. A lobster-like crustacean was also common in this horizon. This is the form described by Prof. R. P. Whitfield as *Hoploparia browni*,[1] closely related to a species of that genus described from the green sand Cretaceous of England.

In this same valley, twenty feet below the base of the Fox Hills and one hundred feet below the base of the fresh-water Hell Creek beds, the remains of a large Trachodont dinosaur were discovered. This specimen was found *in situ*, partly embedded in a large calcareous concretion that was weathered out and broken; the humeri were still covered with shale and well preserved. A collection of characteristic invertebrates was secured on this same level and from a few feet above, all from the undisturbed black shales. They have been identified by Prof. R. P. Whitfield as follows:

Inoceramus sagensis E. & S.,	recognized	from Pierre.
Cardium (*Leptocardia*) *subquadratum* E. & S.,	"	from Fox Hills.
Yoldia evansi M. & H.,	"	from Fox Hills and Pierre.
Pteria (*Oxytoma*) *nebrascana* M. & H.,	"	from Fox Hills and Pierre.
Aporrhais biangulata M. & H.,	"	from Fox Hills and Pierre.
Anchura (*Drepanochilus*) *americana* E. & S.,	"	from Fox Hills.

[1] This Bulletin, Vol. XXIII, 1907, p. 459, pl. xxxvi.

Cinulia (Oligoptycha) concinna H. & M., recognized from Fox Hills and Pierre.
Natica (Lunatia) concinna H. & M., " from Fox Hills and Pierre.
Dentalium gracile ? H. & M., " from Pierre.
Scaphites conradi Morton, " from Fox Hills.
Baculites ovatus Say, " from Fox Hills and Pierre.

This characteristic fauna was found nearly to the top of the black shale.

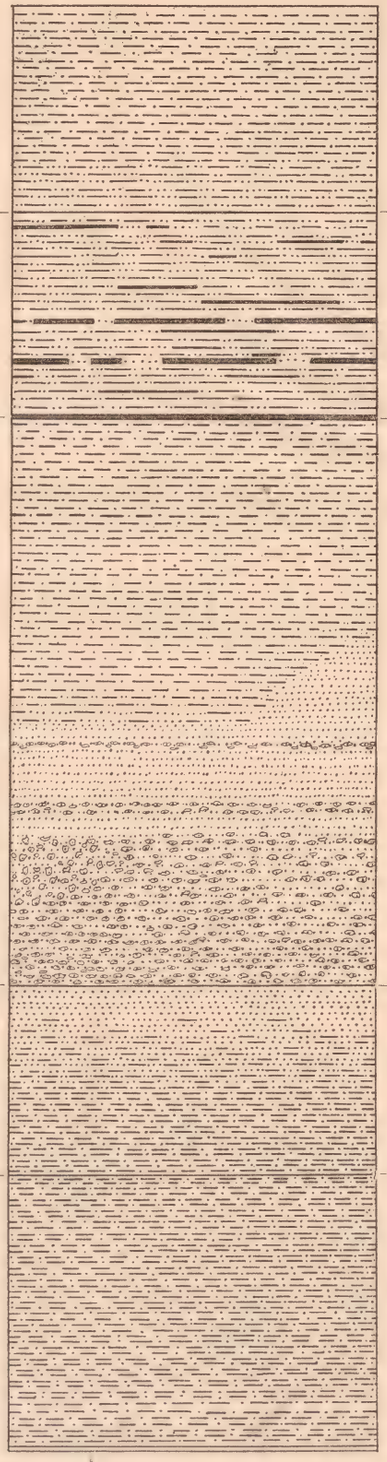
Fox Hills.

This formation was found to be about forty feet thick at the Cook ranch on Crooked Creek, but it increases in thickness to the westward. On Hell Creek it is about eighty feet thick where exposed in clean-cut sections. It consists of soft arenaceous shales and interstratified beds of clay, usually with a capping of sandstone. The clays are grayish yellow and of a decidedly lighter color than the Pierre shales (Fig. 2). They conformably overlie and merge into the darker shales below but a distinct structural change is immediately apparent. On Hell Creek and in that vicinity the apparent unconformity is due entirely to slipping and never shows in a clean-cut section. The clays are highly gypsiferous and the difference in color is most striking. Toward the summit of the clays, thin strata of hard, fine-grained sandstone frequently occur, but are not continuous; they usually show lamellar structure. On Hell Creek this zone is marked by a heavy bed of sandstone six feet thick. Capping the top of the formation there is usually a thin layer of ferruginous, flat concretions of small size. Rounded concretions occur at different levels but always in well stratified planes unlike those in the fresh-water Hell Creek beds above. They are calcareous and formed like those found in the Pierre. No fossils were secured from these beds on the eastern exposure; but on Hell Creek, below the Sensiba Brothers' ranch, the following collection was secured from concretions below the basal sandstones of the Hell Creek beds:

Cardium (Protocardium) subquadratum E. & S., recognized from Fox Hills.
Nucula cancellata M. & H., " " " "
Tellina scitula M. & H., " " " "
Yoldia evansi M. & H., " " " "
Crenella elegantula M. & H., " " " "
Piestochilus culbertsoni M. & H., " " " "
Anchura (Drepanochilus) americana E. & S., " " " "
Lunatia concinna H. & M., " " " "
Cylichna scitula ? M. & H., " " " "
Baculites ovatus Say, " " " " and Pierre.
Scaphites conradi Morton, " " " "
Chemnitzia cerithiformis M. & H., " " " "
Mactra ? nitidula M. & H., " " " "
Actaeon (Oligoptycha) concinnus H. & M., " " " "

Fig. 2. Fox Hills formation overlying dark-colored Pierre shales, Crooked Creek, Montana.

Fig. 3. Diagrammatic section of Hell Creek beds and contiguous formations. Scale, 100 feet to 1 inch.



	VERTEBRATES	INVERTEBRATES	FLORA
Fort Union			"Populus arctica *Heer*" " amblyrhyncha *Ward* " cuneata *Newb.* " nebrascensis *Newb.* " craspedodroma *Ward* " daphnogenoides *Ward* " nervosa *Newb.* Platanus haydenii *Newb.* "Paliurus colombi" *Heer* as determined by *Ward* Sapindus affinis *Newb.* " grandifoliolus *Ward* Cocculus haydenianus *Ward* Calycites polycepalus *Newb.* Leguminosites arachioides *Lesq.* Taxodium occidentale *Newb.* Sequoia nordenskioldi *Heer* Glyptostrobus europæus (Brgt.) *Heer* Corylus macquarrii (Forbes) *Heer* " sp. ? Hicoria antiquorum (Newb.) *Knowlton* Ginkgo adiantoides (Unger) *Heer*
Lignite	Champsosaurus laramiensis " ambulator		Rhamnus salicifolius *Lesq.* Pterospermites sp. Sabalites fructifer ? *Lesq.*
Hell Creek Beds	Ptilodus sp. Meniscoëssus conquistus " sp. Triceratops serratus " brevicornus " sp. Trachodon ? sp. Trachodon sp. Tyrannosaurus rex Ornithomimus altus? Aublysodon sp. Palæoscincus sp. Champsosaurus laramiensis Crocodilus sp. Basilemys sinuosa Adocus lineolatus Compsemys victa " obscura Aspideretes (Trionyx) foveatus " beecheri Scapherpeton tectum? Diphyodus sp. Rhineastes sp. indet. Pappichthys sp. indet. Lepidosteus occidentalis Lana sp.	Unio æsopiformis *Whitf.* " corbiculoides *Whitf.* " pyramidellus *Whitf.* " verrucosiformis *Whitf.* " retusoides *Whitf.* " browni *Whitf.* " percorrugata *Whitf.* " postbiplicata *Whitf.* " aldrichi *White* " danæ *White* " holmesiana *White* " vetusta *Meek* " cryptorhynchus *White* " biasopoides *Whitf.* " cylindricoides *Whitf.* " letsoni *Whitf.* " gibbosoides *Whitf.* " pyramidatoides *Whitf.* " subtrigonalis *Whitf.* Sphærium planum *M. & H.* Corbicula subelliptica *M. & H.* Campeloma multolineata *M. & H.* " vetula *M. & H.* " producta *White* Vivipara plicapressa *White* Cassiopella turricula *White* Thaumastus limnæiformis *White* Bulinus rhomboideus *M. & H.*	Equisetum lævigatum Rhamnus salicifolius Ficus spectabilis Sequoia heerii ?
Fox Hills		Cardium (Protocardium) subquadratum Nucula cancellata Tellina scitula Yoldia evansi Crenella elegantula Piestochilus culbertsoni Anchura (Drepanochilus) americana Lunatia concinna Cylichna scitula ? Baculites ovatus Scaphites conradi Chemnitzia cerithiformis Mactra? nitidula Actaeon (Oligoptycha) concinnus	
Pierre	Trachodont	Inoceramus sagensis *E. & S.* Cardium (Leptocardia) subquadratum *E. & S.* Yoldia evansi *M. & H.* Pteria (Oxytorma) nebrascana *M. & H.* Aporrhais biangulata *M. & H.* Anchura (Drepanochilus) americana *E. & S.* Cinulia (Oligoptycha) concinna *H. & M.* Natica (Lunatia) concinna *H. & M.* Dentalium gracile ? *H. & M.* Scaphites conradi *Morton* Baculites ovatus Say	

Hell Creek Beds.

Overlying the Fox Hills there is a fresh-water deposit that is rich in vertebrate fossils. These beds are exposed on the Yellowstone River at Sentinel Butte near Forsyth; at Glendive; near Ekalaka and at Hockett P. O., south of the Yellowstone. They are probably continuous with the dinosaur-bearing beds of the Little Missouri, and of the Grand and Moreau Rivers, judging from the fauna of the latter districts. These beds, with overlying and underlying deposits, are typically exposed on Hell Creek and nearby tributaries of the Missouri River; hence they have been designated the Hell Creek beds. (Fig. 3.)

The deposit is bounded, roughly speaking, on the west by the Musselshell River. Its eastern and southern boundaries have not been determined. The beds on the northern exposure generally dip to the south and east at an angle of nearly 15° but in some places they are normally horizontal.

The beds may be divided into an upper and a lower member. The former is composed of arenaceous clays alternating with sandstones and carbonaceous matter. The lower member consists of massive sandstone.

Basal sandstone.— This is the most constant of the series. It unconformably overlies the Fox Hills, as shown near the Cook ranch on Crooked Creek; also on Hell Creek. This unconformity is erosional in character. On the east fork of Hell Creek it measures 160 feet in thickness but thins out toward the east. On Gilbert Creek the minimum was found to be less than 40 feet. The average thickness over this whole area is about 80 feet. On the north side of the Missouri most of the upper strata are eroded away and the dip of the beds brings the basal sandstone on the same level with the buff-colored Fort Union on the south side of the river. On account of the similarity in color the Fox Hills on the north side of the river may be mistaken for a continuation of the buff-colored Fort Union on the south side. The sandstones extend on an average about ten miles beyond the river, north of which the Fox Hills and Pierre come to the surface.

The sandstones are fine-grained, massive and usually cross-bedded and composed of angular grains of quartz loosely cemented with carbonate of lime. A characteristic feature of this deposit is the presence of numerous concretions (Fig. 4) that are composed of the same material as the surrounding sandstone but are harder and more compact. They are found throughout the beds. Some are almost perfect spheres and vary from the size of a marble to several feet in diameter. Others are irregular in form. It is not an infrequent sight to see a group of spheres weathered out in a depression like a nest of eggs, or in another place several parallel concretions, circular in cross-section and a hundred feet in length, like fallen trees.

Fig. 4. Basal sandstone showing concretions, Hell Creek beds on Crooked Creek, Montana.

Fig. 5. Sandstone concretion showing concentric structure, Hell Creek beds.

The general tone of color is a light sepia brown. Iron pyrites is abundant, usually formed into perfect spheres from the size of a pea to that of a baseball. The oxidization of the iron probably gives the prevailing color to the sand. The sandstone concretions frequently show concentric structure, as clearly shown in Fig. 5. They often enclose a nucleus of clay lenses, brecciated pebbles or bones, and are so compact that the breaking of the concentric layers gives a loud report. They are not, however, true concretions but centers of solidification. Cross-bedding in the surrounding soft sandstone is frequently carried through the concretions line for line. On the outside they are stained a dark rusty brown; inside they are usually a flinty blue sandstone having a specific gravity nearly equal to that of granite and composed of irregular grains of quartz. This material analyzes as follows.

Carbonate of lime	60 %
Siliceous and feldspathic matter	35 %
Andesytic matter	05 %

Thin strata of carbonaceous matter were found throughout the basal sandstones, and usually imperfect casts of stems and sections of wood were abundant in the concretions. *But nowhere were beds of lignite observed in this member.*

Irregular beds of limestone of an impure quality are frequently found low down, and where exposed in the course of streams have arrested the cutting, forming waterfalls. Near the base, cross-bedding is more pronounced, and numerous thin strata are composed of rounded clay lenses.

Near the eastern border of the outcrop, east of Gilbert Creek, the basal sandstone changes considerably in color, form and texture. The light sepia color changes to a gray, and the massive sandstones are less compactly cemented. They weather rapidly into steep, fluted cañons as shown in Fig. 6. These sandstones simply melt away before a driving rain, like sugar. Concretions are numerous in this zone and are usually globular or lens-shaped. Compact, hard sandstones, showing laminated structure, frequently occur in this eastern region.

Upper beds.— The strata above the basal sandstone are not continuous, but two thin beds of sandstone are usually present, occupying the same relative position wherever found. Both are rich in fossil vertebrates; and consequently were traced for miles.

Immediately overlying the basal sandstone there is a stratum of light blue or slate-colored clay about twelve feet thick which in local sections,

Fig. 6. Basal sandstone, corrugated phase, west fork of Crooked Creek.

as on the east fork of Crooked Creek, increases to a thickness of thirty feet, where it is highly colored, purple at base and light blue above.

Next come the two sandstone strata before mentioned. They are each from twelve to fifteen feet thick and are separated by forty feet of banded clays similar to those above. Both of these strata are considerably lighter in color than the basal sandstone, and cross-bedding is not as marked. Concretions are numerous and similar in form and composition to those found in the basal sandstone. Beds of river-sorted gravel occur in these two strata. They invariably contain waterworn fragments of bones and shells. An example may be seen near Mr. Oscar Hunter's fence near Crooked Creek where the gravel is cemented into a conglomerate capping a low ridge. This bed is a hundred yards long and stained a dark rusty color contrasting with the light color of the surrounding beds. Between these sandstone strata and below them invertebrates are frequently found.

Above the sandstones are a hundred and sixty feet of bluish clays, of a somewhat flocculent structure, composed approximately as follows:

Clay	60 %
Siliceous and feldspathic material	38 %
Tendrilous organic substances	02 %

Mica scales are present and all strata contain a great deal of vegetable substances.

In some localities the clay gives place to pockets of heavy sandstone. On the east fork of Hell Creek the sandstone is capped by a stratum of impure limestone which cleaves into angular fragments at right angles to the bedding plane.

Fort Union?

Lignite beds.— Overlying the dinosaur clays are the lignite series which apparently represent an uninterrupted continuation of the former. These beds on Hell Creek are 100 feet thick, increasing in thickness toward the south. At Miles City over 400 feet are exposed, and I was informed by a well-driller of that town that he had bored through a four foot vein of coal over a hundred feet below the river level in the valley of the Yellowstone.

These beds are characterized by the large amount of carbonaceous matter and frequent veins of lignite. A section taken on the east fork of Hell Creek shows as follows: Capping the dinosaur clays there is a vein of lignite about 4 feet thick, followed by 25 feet of arenaceous clays interlined with very thin strata of sandstone, usually cross-bedded. Frequent layers of flattened chert pebbles, having skins of limonite encrusted over them, are found at the base and more or less throughout the lignites. These peb-

bles have the lustre of gun-metal and when struck ring like steel. They were probably formed on the floor of shallow ponds or in bog land. Above this stratum is another vein of lignite followed by 20 feet of clays and sandstone of a dark grayish brown color, which are capped by a third vein of lignite about three feet in thickness. This is the purest vein exposed on Hell Creek. It burns to a light ash with few clinkers and under forced draft will fuse steel. Above this vein there are about 40 feet of very light-colored sand which merges into a light ocherous-yellow or buff-colored clay.

A few indeterminable casts of shells were found in the lignite associated with the chert. Also a few distorted leaves identified by Dr. Arthur Hollick as *Rhamnus salicifolius* Lesq. and *Pterospermites* sp.; also a mass of seeds resembling *Sabalites fructifer* Lesq. These came from just above the lowest vein of lignite. Crocodile, turtle and rhyncocephalian remains were found all through the lignite but most abundant and best preserved near the base. This is the horizon in which *Champsosaurus laramiensis*[1] and *C. ambulator* were discovered.

It is a most remarkable and significant fact that in no instance has a fragment of dinosaur bones been found in or above the lignite series by any of our party during five years' work in this region.

For this reason I have considered the lignites separately. They probably belong to the Fort Union age. Species of such genera as *Champosaurus, Adocus* and *Crocodilus,* which have persisted unchanged through two or more long geological periods, cannot be considered as diagnostic of a formation. But the sudden termination of the many highly specialized forms of dinosaurs indicates a considerable time hiatus or a sudden and marked change in geological conditions.

Throughout this whole region the lignite veins have been fired in different places, sometimes burning over considerable areas. The beds have probably taken fire by spontaneous combustion, prairie fires or lightning. The overlying and underlying rocks have thus been altered to a considerable degree. Frequently the strata have been fused, developing both flow and vesicular structure, closely resembling lavas. North of Jordan many of the hill tops are covered with such fused material which stand out as monuments. In a less fused condition, where the strata have simply been hardened, it has arrested degradation leaving hills capped with rose colored, indurated shales.

Fort Union.

The identified Fort Union, which is distinguished by its light buff color, overlies the lignites. The beds are composed of very fine-grained sand-

[1] Brown, Mem. Am. Mus. of Nat. Hist., Vol. IX, pt. I, 1905.

stone, impure limestones and highly micaceous shales with occasional veins of lignite. The sandstones are lamellar in structure and in most places are rich in impressions of a characteristic Fort Union flora. Leaf impressions are found in many places over the divide between the Missouri and the Yellowstone Rivers, on the head of Hell Creek, on the Little Dry, at Red Butte ranch, and near the top of Signal Butte, south of Miles City. These impressions are in most instances perfectly preserved. They have been identified by Dr. F. H. Knowlton as follows:

From Smoke Butte Creek, 14 miles northwest of Jordan.

Populus arctica Heer, as identified by Lesq.
Populus amblyrhyncha Ward.
Populus cuneata Newb.
Populus nebrascensis Newb.
Populus craspedodroma Ward.
Populus daphnogenoides Ward.
Populus nervosa Newb.
Platanus raynoldsii Newb.
Platanus haydenii Newb.
Paliurus colombi Heer, as determined by Ward.
Sapindus affinis Newb.
Sapindus grandifoliolus Ward.
Cocculus haydenianus Ward.
Calycites polycepalus Newb.
Leguminosites arachioides Lesq.

From Vail Creek, 100 feet above Hell Creek beds.

Taxodium occidentale Newb.
Sequoia nordenskiöldi Heer ?
Glyptostrobus europæus (Brgt.) Heer.

From Little Dry, 24 miles southwest of Jordan.

Glyptostrobus europæus (Brgt.) Heer.
Corylus macquarrii (Forbes) Heer.
Corylus sp. ?

From ridge 50 miles northwest of Miles City.

Hicoria antiquorum (Newb.) Knowlton.
Ginkgo adiantoides (Unger) Heer.

The strata containing this flora are horizontal and were evidently laid down under more uniform conditions than the underlying Hell Creek beds. On Signal Butte, near Miles City, a four-foot ledge of sandstone separates the lignites from the buff-colored Fort Union. This sandstone is not continuous but the light color and finer grained material always defines this zone. About 120 feet of identified Fort Union forms the top of Signal Butte, which is capped, like the surrounding hills, with rose-red indurated shales altered by fired veins of lignite, as noted in the lignite beds.

About six miles above Jordan on the Big Dry there is a landmark famous in that section of the country, named Smoke Butte (Fig. 7). It is visible for many miles and stands out as a monument, nearly 200 (estimated) feet

above the surrounding country. It was near here that the last of the great buffalo herds was killed.

The butte is of igneous origin and is connected with lesser buttes on either side by a dyke. The dyke is composed of highly vesicular andesyte. The vesicles are uniformly parallel, pyriform or cylindrical, and lined with calcite crystals. Some of the vesicles are half an inch in diameter and more than an inch in length. All are vertical. The dyke varies from one to three feet in width. Apparently its extrusion caused little if any alteration in the confining sedimentary strata and no displacement of the buff-colored Fort Union beds, which are perfectly horizontal on either side (Fig. 8). The buttes, which are cones, are simply large plugs, and there is no evidence of a flow anywhere in the country.

Several other dykes were seen on the west side of Smoke Butte Creek but were not examined. The buttes and dykes were evidently formed subsequent to the deposition of the lignites, probably during the latter part of the Fort Union age.

Presence and Condition of Fossils in Hell Creek Beds.

Invertebrates.

Invertebrate fossils were found in several localities in the upper clays. East of the main branch of Hell Creek, about two miles southeast of Sensiba Brothers' ranch, they are especially abundant and so well preserved that even the hinge ligament is often present. This locality furnished representatives of nearly all the species collected. The basal sandstone contains few invertebrates and they are rarely well preserved. Unios were invariably the common forms found in the lower levels.

The invertebrates of the Hell Creek beds are a purely fresh-water fauna with the exception of the brackish or fresh-water genus *Corbicula* and the land genus *Bulinus*. The collection is especially rich in Unios, both in numbers and species. In the list given below a large number of the Unios have been found only in the Hell Creek beds, while three species have been found in the Converse County beds also.

Unio æsopiformis Whitf.
" *corbiculoides* Whitf.
" *verrucosiformis* Whitf.
" *retusoides* Whitf.
" *browni* Whitf.
" *percorrugata* Whitf.
" *postbiplicata* Whitf.
" aldrichi White.
Unio letsoni Whitf.
" *pyramidellus* Whitf.
" *gibbosoides* Whitf.
" *pyramidatoides* Whitf.
" *subtrigonalis* Whitf.
Sphærium planum M. & H.
Corbicula subelliptica M. & H.
Campeloma multolineata M. & H.

Fig. 7. Smoke Butte with dyke and lesser cones,

Fig. 8. Smoke Butte and undisturbed Fort Union strata on either side of dyke.

Unio dance M. & H.
" *holmesiana* White.
" *vetusta* Meek.
" *cryptorhynchus* White.
" *biesopoides* Whitf.
" *cylindricoides* Whitf.
Campeloma vetula M. & H.
" *producta* White.
Vivipara plicapressa White.
Cassiopella turricula White.
Thaumastus limnæiformis White.
Bulinus rhomboideus M. & H.

In discussing this fauna and comparing it with living forms Prof. R. P. Whitfield says: "Considering all the similarities between these Laramie fossils and their representative species in the Mississippi and Ohio watersheds, I venture to state that these farther western waters of the Laramie times were the original home of much of the *Unio* fauna of these more eastern recent localities."[1]

Vertebrates.

Vertebrate fossils are found throughout the Hell Creek beds. Rarest of these are the remains of mammals, which are represented by single teeth with an occasional fragmentary limb bone or vertebra. These remains are nearly always associated with ganoid fish scales, vertebræ and washed bones, and in the Hell Creek region were always found at the base of the two prominent sandstone strata in the upper beds. The teeth are very small and difficult to see; frequently they are conspicuous on ant-hills favorably located in one of these beds of water-washed material, where they have been separated from the finer sand and carried out with pieces of small gravel.

The almost total absence of mammal remains from strata in which dinosaurs are common indicates a difference in habitat of the two groups. It is noteworthy that these remains have always been found in water-worn debris. They may represent river arboreal types. It is highly probable that the mammalian plains fauna of Laramie times has not yet been recognized. Several different forms of multituberculate and tritubercular teeth are represented, but as only a few of these can certainly be associated it would be hazardous to identify them with separate teeth that have been found in other localities. The genera *Ptilodus* and *Meniscoëssus* are represented by teeth indicating two or more species. *Ptilodus,* and *Polymastodon,* a genus closely related to *Meniscoëssus,* are found in the lowest Eocene and the species here represented indicate a closer affinity to the lower Eocene mammals than to the same genera of the Jurassic. The difference between the mammalian fauna of the Puerco and that of the Laramie series, however, is greater than between the Puerco and the Wasatch formations.

[1] This Bulletin, XXIII, 1907, p. 624.

Of the dinosaurs the Ceratopsia seem to have been most abundant. Remains of *Triceratops* are found from the very base of the sandstone to the top of the beds. At least two hundred skulls were found in this formation during our work, but in nearly every case they were so badly broken as to be of little value in specific determinations. Invariably when found in the soft clays the skulls are badly crushed and usually broken. The bones are nearly always scattered; seldom are there found in one place more than a skull or a few vertebræ and ribs, possibly a limb associated. Some of this material has not yet been identified, while in other cases it represents undescribed species. The genus *Torosaurus,* which frequently occurs in the Converse County beds of Wyoming, has not been found in the Hell Creek beds.

Next to the Ceratopsia in frequency of occurrence are found representatives of the Trachodontidæ. These forms usually have the greater part of the skeleton associated, which is probably due to two or more reasons: (1) Members of this family were probably primarily aquatic. (2) The great number of ossified tendons lying along the transverse processes of the vertebræ bound the skeleton together even after the flesh was decomposed. (3) The opisthocœlus form of vertebræ with locking zygapophyses further bound the skeleton together. The fossils found in the Hell Creek beds so far are species having teeth with smooth borders, a character that is considered more specialized than those having crenulated borders. One of these species having teeth with smooth borders is common to the Converse County beds.

Carnivorous dinosaur remains are rare and are most frequently found in the lower sandstones, usually in concretions. The largest of these, *Tyrannosaurus rex,* has also been found in the Converse County beds of Wyoming.

During this period there were many small dinosaurs of which we know comparatively little. They are represented by single teeth, vertebræ and phalanges. Similar teeth have been found in the Converse County beds.

Turtles are quite common but complete shells are rare; nearly all the genera and species are common to the Converse County beds. Crocodiles and Champsosaur vertebræ are found in all upper levels but skeletons were confined to the overlying lignites.

Isolated fish scales, vertebræ and plates occur in the clays, usually at the base of the two prominent sandstone strata in the upper beds overlying the basal sandstone where they are found in quantities. Urodele vertebræ are usually associated with these fish scales. Dr. Charles R. Eastman and Dr. L. Hussakof have examined the fish remains, but report the material so fragmentary that only a few genera can be recognized with certainty. Of

these genera probably the most interesting is the shark *Lamna*, represented by a single tooth. This is the only known marine genus represented in the collection. Among living sharks, however, this form has been found in rivers far from the sea, so that its presence in this inland fresh-water deposit is not of especial import. In discussing these fragmentary remains Dr. Eastman writes me: "As a whole the collection does not have a decided Cretaceous aspect. Nevertheless, it would be useless to argue from this that the beds in question are of Eocene age, for there are numerous fishes of preponderating Eocene type in the Fort Benton Cretaceous of Wyoming."

When found in the sandstones, vertebrate fossils are well preserved and rarely crushed, but in the clays they are almost invariably crushed and badly broken. The genera and species of vertebrate fossils identified from the Hell Creek beds are as follows:

List of Vertebrates.

Ptilodus sp.
Meniscoëssus conquistus Cope.
Meniscoëssus sp.
Triceratops serratus Marsh.
Triceratops brevicornus Marsh.
Triceratops sp.
Trachodon ? sp.
Trachodon sp.
Tyrannosaurus rex Osborn.
Ornithomimus altus ? Lamb.
Aublysodon sp.
Palæoscincus sp.
Champsosaurus laramiensis Brown.
Crocodilus sp.
Basilemys sinuosa Riggs.
Adocus lineolatus Cope
Compsemys victa Leidy.
Compsemys obscura Leidy.
Aspideretes (*Trionyx*) *foveatus* Leidy.
Aspideretes beecheri Hay.
Scapherpeton tectum ? Cope.
Diphyodus sp.
Rhineastes sp. indet.
Pappichthys sp. indet.
Lepidosteus occidentalis Leidy.
Lamna sp.

Flora.

Although fossil leaves, stems and fruits are of common occurrence in these beds very little of the material is sufficiently well preserved for identification. All the identifiable material comes from the upper beds, above the basal sandstone. So far only three or four identifiable species have been preserved, as *Equisetum lævigatum, Rhamnus salicifolius* Lesq., *Ficus spectabilis* Lesq. Only one of these, a fruit identified by Dr. Knowlton as *Ficus*, is common to the Converse County beds.

There is a series of lignite beds overlying the Converse County beds similar to those overlying the Hell Creek beds. In 1900 I obtained a collection of leaf impressions near the base of these beds on Seven Mile Creek, 40 miles northwest of Edgemont, S. D. At that time I was unable to define the limits of the dinosaur horizon and the fossils were marked "Ceratops beds?" Dr. Knowlton has identified the collection as follows:

Taxodium occidentale Newb.
Sequoia nordenskiöldi ? Heer.
Dammara sp.
Platanus raynoldsii Newb.
Platanus sp.
Quercus sp.
Carpites sp.

They are said to be a typical Fort Union flora from near the base of the formation. As far as identified the species agree with those found in the Fort Union near Hell Creek, Mont. Another collection from the same locality on Seven Mile Creek, but lower and associated with a dinosaur skeleton, *Claosaurus annectens* Marsh, were identified as follows.

Sequoia heerii Lesq.
Taxodium distichum miocenum (Brongn.) Heer.
Ginkgo adiantoides Heer.
Musophyllum sp. probably new.
Flabellaria eocenica Lesq.
Sabalites grayanus Lesq.
Palmocarpom palmarum (Lesq.) Knowlton.
Platanus rhomboidea Lesq.
Platanus sp.
Ficus spectabilis Lesq.
Viburnum sp.

Although the horizons from which these two collections were obtained are separated by less than two hundred vertical feet the species are not common to both horizons. Dr. Knowlton has kindly furnished me with the following data regarding the latter flora: "*Sequoia heerii* was described from the supposed Green River group at Sage Creek, Mont., and has been found in the upper Clarno beds (upper Eocene) of Bridge Creek, Oregon, as well as Bull Mountains, Montana, in beds supposed to be lower Fort Union, but which may be similar in age to the beds on Hell Creek. *Taxodium distichum miocenum* is a species of wide distribution in the Miocene, but has also been found in the Fort Union beds, the Eocene beds of Elko, Nevada, and in the Ceratops beds of Converse County, Wyoming. The *Musophyllum* is not widely different from *M. complicatum* Lesq., but is probably new to science. *Flabbellaria eocenica* was described from the supposed Laramie at Black Buttes, Wyoming, and has been found also in the Ceratops beds of Converse County, and in the Denver beds at Golden, Colorado. *Sabalites grayanus* is, generally speaking, a Laramie species, though it has also been doubtfully reported from Montana. *Palmocarpon palmarum, Sabalites fructifer, Platanus rhomboidea, Equisetum lævigatum,* and *Ficus spectabilis* are known only, or mainly, from the Denver beds at Golden, Colorado.

"The main point brought out by this small flora is the fact that it shows practically no affinity with the true Laramie, while it does indicate a strong agreement with the Denver beds of Colorado. It is proportionately very much stronger in this direction than is indicated by previous studies of the flora of the Ceratops beds of Converse County. Thus, of a total of 48

forms in the Ceratops beds of Converse County, 36 prove to be new to science, leaving only 12 species with an outside distribution. Of these 3 have been found in the Fort Union, 6 in the Post-Laramie, 5 in the Laramie, 6 in the Montana."

Correlation and Age.

Lithologically the Hell Creek beds of Montana are similar in almost every respect to the Ceratops beds of Converse County, Wyoming. Most genera and many species of vertebrates and invertebrates are common to both deposits, while the faunal facies may be considered a unit, taking into consideration the separation of localities, which may account for absence of common genera in the one or the other locality. They are therefore considered of contemporaneous deposition. Where I have examined the two deposits I have found that they have the same relation to contiguous formations. In an article entitled 'The Ceratops Beds of Converse County, Wyoming,[1] Mr. J. B. Hatcher says: "Immediately above the Fox Hills is a very thin, but quite persistent, layer of hard sandstone, well stratified and quite cleavable along the lines of stratification. This stratum of sandstone is about six inches thick, and is regarded as the dividing line between the marine and fresh-water beds. It is overlaid by about 150 feet of yellowish brown, well stratified sandstones apparently non-fossiliferous. These are in turn overlaid by about 250 feet of almost white, fine-grained, massive sandstone with numerous concretions, but no fossils were found in them. Next comes the fossiliferous portion of the Ceratops beds, consisting, as before stated, of alternating sandstones, shales, and lignites." In the same article he says that the Ceratops beds conformably overlie the Fox Hills.

The non-fossiliferous beds described by Mr. Hatcher are not present in the Hell Creek region of Montana but may be represented on the Yellowstone between Huntly Flats and Forsyth by the barren sandstones that closely resemble in character the Hell Creek basal sandstones.

In another article entitled 'Laramie Mammals and Horned Dinosaurs,'[2] Mr. Hatcher says: "At no place in the Converse County region do the true Ceratops beds, with the remains of horned dinosaurs, rest upon true marine Fox Hills sediments; nor are the Ceratops beds in this region overlaid by strata which could be referred without doubt to the Laramie."

Now, the first part of this statement does not hold good for the northern border of those beds which are exposed in Weston County. On Alkali Creek, about thirty-five miles northeast of Edgemont, S. D., and six miles

[1] Am. Jour. Sci., Vol. XLV, pp. 135–144, 1893.
[2] Am. Nat., p. 117, 1896.

north of the Cheyenne River, the dinosaur bearing beds do rest on the marine Fox Hills. In 1901 I obtained characteristic fossils from both formations near their contact at that locality. At that place the conditions are similar to those in the Hell Creek region.

Strictly following King's definition of the Laramie, neither of these deposits can be considered as such, for neither one represents a continuous sedimentation from the marine Fox Hills. They should therefore be grouped with the Livingston, Denver, and Arapahoe beds and may be considered Post-Laramie, if indeed the type locality of the Laramie does prove upon further investigation to represent a continuous sedimentation from the Fox Hills times.

The close relation of the vertebrate fauna and flora of the Denver beds to the Converse County beds and Hell Creek beds, as well as the presence of andesytic material in the latter, indicates that the three are of contemporaneous age, the two last-named representing plains zones where sedimentation was less rapid.

Considering the evidence of the organic remains, the invertebrates plainly foreshadow Tertiary and living species. The flora on the other hand shows very little affinity with that of the true Laramie and even less with the Fort Union above. The vertebrates are clearly of mesozoic affinity. The dinosaurs here represented in the Post-Laramie are the culmination of a practically uninterrupted line of highly organized vertebrates that have persisted with little change since the Judith River period, some, like *Claosaurus*, extending as far back as the Niobrara, and their relation to the earlier Jarassic forms is well established.

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Article XXXIV.— DESCRIPTIONS OF SEVEN NEW SPECIES OF TURTLES FROM THE TERTIARY OF THE UNITED STATES.

By Oliver P. Hay.

Plate LIV and 20 Text-figures.

The writer here presents descriptions of seven fossil turtles, all of which appear to have been hitherto unknown. One of these is an alligator snapper, the scanty remains of which were found in what are regarded as Pliocene deposits, on the western coast of Florida. This turtle was about the size of the alligator snapper, *Macrochelys temmincki*, which now inhabits the region from western Georgia to Texas. In structure the fossil species is quite distinct from its modern representative. Another interesting species is a new box-tortoise which was found in Pliocene or early Pleistocene deposits near Savannah, Georgia, and which exceeded in size any living species of box-tortoise.

A new and beautifully sculptured species of *Plastomenus* comes from the Basal Eocene, probably from the Torrejon beds, of New Mexico. A fine large soft-shelled turtle of the genus *Aspideretes*, was found in the Cope collection of fossil reptiles, having been labeled by Professor Cope as *Trionyx* and as coming from the Upper Puerco (Torrejon) of New Mexico. This is one of the best preserved turtles known and, excepting *Conchochelys admirabilis*, furnishes the oldest known skull of the family. There is also a new species of *Plastomenus* from the Basal Eocene. Finally, three Eocene species of the genus *Platypeltis* are described, a genus represented today by several species that inhabit the rivers of North America east of the Rocky Mountains.

Macrochelys floridana sp. nov.

Figs. 1–4.

Four peripheral bones found in the Jarman collection of fossils made in Hillsborough County, Florida, and now the property of Vanderbilt University, Nashville, Tennessee, indicate a hitherto undescribed species of alligator snapper, to which the above name is given. These bones were accompanied by those of various other turtles, among them *Testudo crassi-*

scutata, and species as yet undescribed, and by bones of a horse and plates of *Chlamytherium humboldti.* The deposits appear to belong to what are known as the Peace Creek beds.

It is probable that these peripherals belong to as many individuals. One of these bones is the fourth peripheral of the left side; another is the seventh of the right side; a third, the seventh of the left side; the fourth, the ninth of the right side. These bones have been carefully compared with the corresponding bones of an excellent skeleton of *Macrochelys temmincki* and found to be quite distinct.

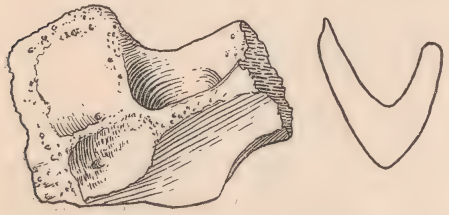

Fig. 1. *Macrochelys floridana* Hay. Fourth left peripheral seen from below. Presents a pit for second costal and an excavation for the hypoplastron. On the right is a section across the bone about the middle of its length. × ⅔.

The fourth peripheral (Fig. 1) is 46 mm. long; its greatest height is 34 mm.; its thickness, 21 mm. The upper and the lower faces are moderately convex and they meet to form a free border which is subacute anteriorly, but more obtuse posteriorly. The inner face contains a large nearly circular pit for the end of the rib of the second costal. This pit is mostly in the anterior half of the face. Below and behind the pit is an excavation for the outer anterior angle of the hyoplastron. This excavation is 18 mm. long. On the upper face are seen the costomarginal sulcus and that between the fourth and fifth marginal scutes. The former runs near the upper border of the bone. The latter ascends between the middle and posterior thirds of the length of the bone. The upper border of the bone has the portion behind the pit thickened, as if it had articulated suturally with the costal; but this is not certain. The remainder of the border is thin and sharp.

Fig. 2. *Macrochelys floridana* Hay. Right seventh peripheral, seen from above. On the right is a section across the bone about the middle of the length. × ⅔.

In *M. temmincki* this bone has the upper face much more convex and it rounds into the lower face so that the keel is hardly perceptible. The pit for the rib is nearer the hinder end of the bone and there is no excavation for the hyoplastron, the latter bone coming forward just to its hinder end.

The larger seventh peripheral (Figs. 2, 3) of the fossil species has a length of 60 mm. along the free border, a maximum thickness of 25 mm., and a

height of 50 mm.; but as the anterior end of the upper border has been broken away, the height may have been slightly greater. At the posterior end the height is 48 mm. The free border is distinctly acute. From this the upper and the lower borders ascend with slight convexity. On the upper face the sulcus between the seventh and eighth marginals ascends between the third and fourth quarters of the length of the bone. The costomarginal sulcus runs in a nearly straight line about 32 mm. above the free border. The sulcus between the second and third costal scutes ascends about the middle of the length of the bone. The pit for the fifth rib is in the hinder half. Below and in front of this pit is an excavation 32 mm. long for the outer hinder angle of the hypoplastron. The upper border of the bone, so far as present, shows that it articulated strongly by a jagged suture with the lower border of the fifth costal.

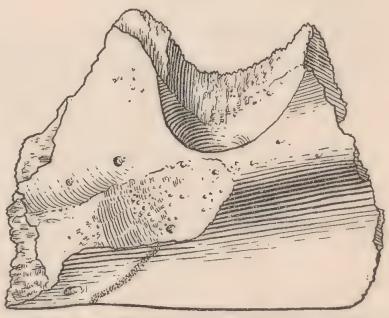

Fig. 3. *Macrochelys floridana* Hay. Right seventh peripheral seen from below. Presents pit for the fifth rib and an excavation for the hypoplastron. × ⅔.

The corresponding bone in *M. temmincki* has the pit for the rib and the excavation for the hypoplastron similarly placed. It differs from that of *M. floridana* in having a much more obtuse free border, but especially in not having been in contact with the costal. In the specimen examined there is a fontanel between the costal and the peripheral from 10 mm. to 23 mm. in height. On the upper face the ascending sulcus is not so near the anterior end of the bone as in *M. floridana*. The costomarginal sulcus on the anterior half of the bone is about halfway between the upper and the lower border, but it suddenly descends to near the lower border.

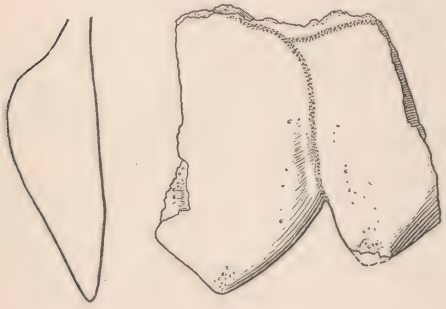

Fig. 4. *Macrochelys floridana* Hay. Right ninth peripheral seen from above, with section taken across the hinder end. × ⅔.

The other seventh peripheral belonged to a smaller individual and offers no additional data.

The ninth peripheral (Fig. 4) is 48 mm. long, 48 mm. high, and 15 mm. thick. The front of the upper border is broken away. The hinder half of the border, and probably also the anterior half, articulated with the seventh costal. The upper face has an undulating surface, but only slight convexity. The sulcus between the ninth and the tenth marginals ascends a little in front of the middle of the

bone. The costomarginal sulcus runs near the upper border. The pit for the rib is rather small. In the free border is a deep notch. In front of this notch is an obtuse process of the border and behind it follows another less obtuse. To judge from this peripheral, there were two processes on the free border of each hinder peripheral.

The corresponding bone of *M. temmincki* differs in having only a single point or process on the free border, the one just in front of the end of the ascending sulcus.

From the materials at hand it appears that in *M. floridana* the distal ends of the costals were more closely connected with the peripherals and that the whole free border was less obtuse than in *M. temmincki.*

In case future discoveries should reveal the fact that two or more species are included in the bones here described the seventh right peripheral is to be taken as the type.

Terrapene canaliculata sp. nov.

Figs. 5–7.

This species has as its type a lot of bones which belong to the U. S. National Museum. I am informed by Mr. J. W. Gidley of that museum that they were with and apparently belong to a lot of fossils of Pliocene or Pleistocene age that were collected probably previous to 1869, at Whitemarsh Island or Skedaway Island, Georgia, by Dr. J. P. Scriver. These islands lie southeast of Savannah. The bones have the catalogue number 8211. It is certain they were found in deposits near the coast, inasmuch as some of them are partly incrusted by worm tubes, bryozoa, and barnacles.

The shell only is represented. The fourth right peripheral presents its thicker portion. The region covered by the seventh and eighth right marginal scutes and parts of the second and third costals is represented by one fragment. Another fragment comes from the midline of the back, apparently including a part of the fifth neural. There are also portions of costals, all lacking the proximal end. Of the plastron there is the complete entoplastron and a considerable part of the left side of the hinder lobe. The individual had a size larger than that of any living box-tortoise. It was aged, for in many cases the sutures are wholly obliterated.

The fragment of the dorsal region extends 22 mm. on each side of the midline. It is crossed by part of one sulcus, probably that between the third and fourth vertebral scutes. From side to side the fragment is strongly concave and there is no trace of a median carina, so usual on the carapace of these animals. It is possible that it would appear farther in front and behind.

The fourth right peripheral (Fig. 5) is 26 mm. long; its anterior end (Fig. 5) 8 mm. thick; its hinder end (Fig. 5), approaching the lateral hinge, is 19 mm. thick. The sharp free border of the more anterior peripherals is continued on this fourth as a sharp keel, which forms the outer boundary of a sort of gutter running above the bridge. The width of the gutter varies from 4 mm. to 7 mm.

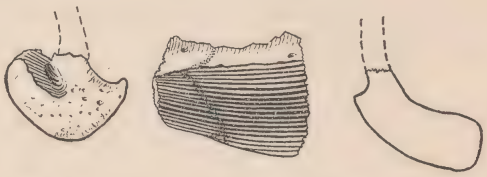

Fig. 5. *Terrapene canaliculata* Hay. Fourth right peripheral seen from without. On the right is a section of the front end; on the left, a section of the hinder end. × ⅔.

The fragment occupied by the seventh and eighth marginal scutes and parts of the second and third costal scutes (Fig. 6) has the sutures obliterated. The lower ends of the costal bones present are 5 mm. thick. The hinge line, of which there remains 30 mm., is 10 mm. thick. That of *T. putnami*, of about the same size, is 14 mm. thick. On the front end of the fragment there is a segment of the sulcus between the sixth and seventh marginals. The seventh is thus seen to have been 32 mm. long. Its height above the lateral carina varies from 21 mm. to 25 mm. Figure 6 presents a perpendicular section through this fragment taken near the right side.

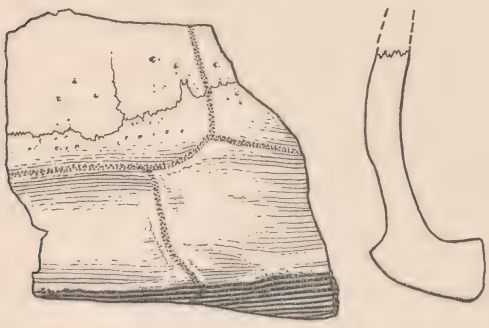

Fig. 6. *Terrapene canaliculata* Hay. Region of sixth and seventh marginal scutes, right side. On right is a section near front end of fragment. × ⅔.

After comparison with the shells of living species it is concluded that an interval of about 40 mm. is missing between the fourth peripheral and the one just described. This makes the length of the hinge-line about 70 mm.

The lower end of a costal bone, probably the third, is 34 mm. wide and 4.3 mm. thick. Other costals are 6 mm. thick.

The entoplastron (Fig. 7) is subcircular, 34 mm. long, and 37 mm. wide. At the end of the hyoepiplastral suture the thickness is 7 mm. The gular scutes overlapped somewhat the anterior end, while the pectorals extended forward on the hinder end.

Fig. 7. *Terrapene canaliculata* Hay. Entoplastron. × ⅔.

The border of the hinder lobe thickens rapidly from the free edge, at-

taining at a short distance behind the hinge a thickness of 13.5 mm. At the femoroanal sulcus the thickness is 10.5 mm. There is no emargination of the free border where it is crossed by the femoroanal sulcus. The inferior surface of the fragment indicates that the hinder lobe was rather strongly convex in all directions.

Plastomenus acupictus sp. nov.

PLATE LIV, FIGS. 1–3, AND TEXT-FIG. 8.

The somewhat scanty remains that constitute the type of this species were recently found in some neglected materials of the Cope collection. The most important parts belong to the left side of the animal. There are, first, parts of two costals, probably the third and fourth, but possibly the second and the third; also the proximal half of the sixth costal and the whole of the seventh; finally, considerable portions of the hypoplastron and the xiphiplastron. The specimen was collected many years ago, perhaps in 1883, by David Baldwin, in New Mexico. It accompanies other fossils from the Torrejon deposits and was itself probably derived from the Torrejon. The exact locality is unknown, but is in the region lying north of Santa Fé. The specimen bears the catalogue number 1025 of the American Museum of Natural History.

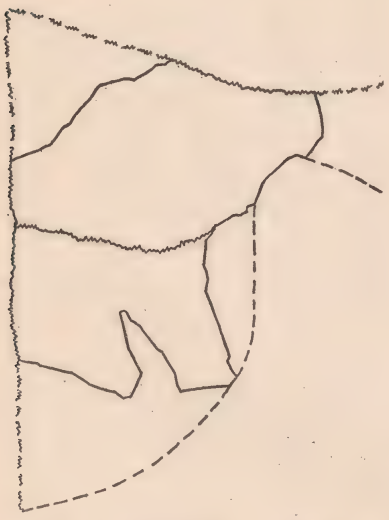

Fig. 8. *Plastomenus acupictus* Hay. Portions of left hypoplastron and xiphiplastron. × 1.

That the species belongs to *Plastomenus* is shown by the fact that the hypoplastron and the xiphiplastron were both suturally joined to their fellow bones as far as represented by the specimen; that is, along 8 mm. of the hinder part of the hypoplastron and 16 mm. of the anterior portion of the xiphiplastron.

The supposed third costal (Plate LIV, Fig. 1) is 10 mm. wide proximally, 3 mm. thick along the neural border, and 2.5 mm. thick on the sutural edge at a distance of 13 mm. from the neural border. The seventh costal (Plate LIV, Fig. 2) is, at the distal end, 16 mm. wide, 3 mm. thick where it joined the contiguous costals, and 4.5 mm. thick through the ridge formed by the rib. Each eighth costal (Plate LIV, Fig. 2) must have had a fore and aft extent of about 23 mm. and a lateral extent of close to the same amount.

The free border of the costals is beveled off on the upper side. A fragment of the nuchal shows that its free border was similarly beveled.

On the hinder costals are seen six or seven welts which run backward and somewhat outward. The whole upper surface of the shell, except the beveled border, is ornamented with small pits and narrow intervening ridges. There are five of the pits in as many millimeters.

The hypoplastron and the xiphiplastron measure 27 mm. along their common suture. The width of the hinder lobe (Plate LIV, Fig. 3, and Text-fig. 8) was close to 60 mm. At the bridge the hypoplastron is only 8 mm. wide, while it is 5 mm. thick. The sutural border of the bone in this region is concave. The antero-inner angle of this bone and that portion beyond the bridge are missing; as is also the hinder end of the xiphiplastron. At a distance of 18 mm. behind its anterior end the free border of the xiphiplastron is preserved for a short distance. It is there thin and acute.

The sculpture of the xiphiplastron resembles that of the carapace, but there are no welts and the pits are somewhat smaller.

Aspideretes singularis sp. nov.

Plate LIV, Fig. 4, and Text-figs. 9–17.

The type of the present species belongs to the American Museum of Natural History and has the catalogue number 1028. The specimen is beautifully preserved and furnishes the nearly complete skeleton. It was collected for Professor E. D. Cope by David Baldwin, in 1883, in the Torrejon beds, the upper division of the Puerco formation, of the Basal Eocene. The locality is recorded as having been the Chaco Cañon, in the southern part of San Juan County, New Mexico. Only one other skull belonging to the Trionychoidea is at present known that is older, that of *Conchochelys admirabilis,* of the Lower Puerco; no other trionychoid skull so old is known that is accompanied by the shell. The specimen is therefore interesting because it shows how little change has taken place in the group since Basal Eocene times.

The carapace (Fig. 9) is elliptical and appears to have been rather convex, but this convexity has been considerably increased during fossilization. The length is 350 mm. in a straight line; the width of the disk appears not to have exceeded 280 mm. The carapace is composed of the nuchal, a preneural, seven neurals, and eight pairs of costals.

The nuchal has a lateral extent of 190 mm.; a fore and aft extent of 37 mm. The outer ends of the bone are smooth; the median portion is pitted.

The outer ends of the nuchal overlap strongly the projecting ends of the ribs of the costals of the first pair. The following are the dimensions in millimeters of the other median bones:

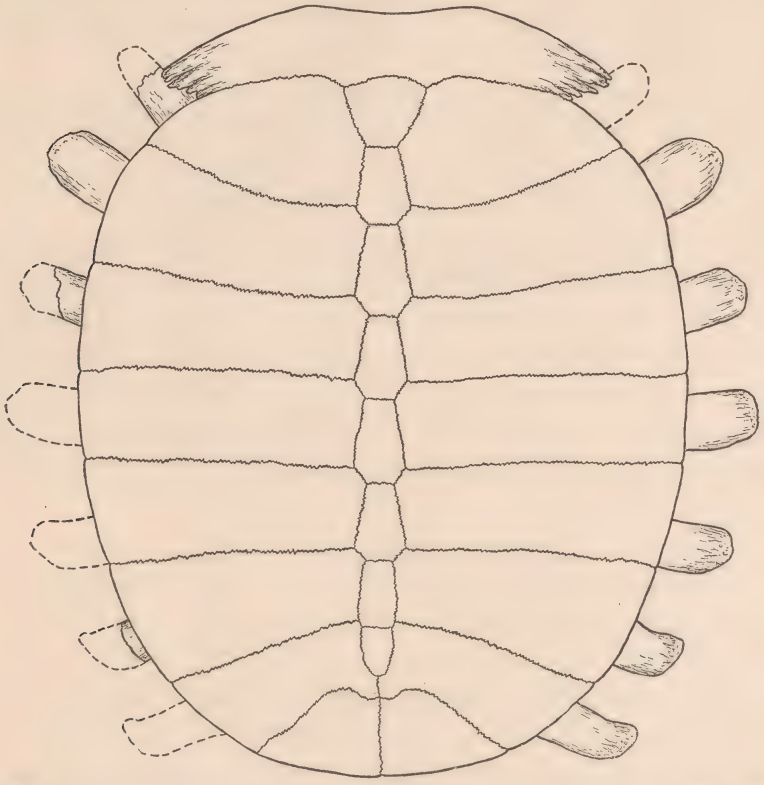

Fig. 9. *Aspidercles singularis* Hay. Carapace of type. No. 1028, A. M. N. H. × ¼.

Element		Length	Width
Preneural		34	42
Neural	1	34	27
	2	38	27
	3	42	25
	4	38	24
	5	35	23
	6	31	19
	7	24	16

The costals of the eighth pair join on the midline and extend laterally each 60 mm. The free borders of the carapace are beveled off and are smooth. The ends of the ribs extend beyond the borders of the disk about 50 mm. and vary in width from 25 mm. to 33 mm.

The sculpture (Plate LIV, Fig. 4) consists of pits with prominent intervening ridges. On the neurals and the proximal ends of the costals the pits

are nearly circular and there are from six to eight in a line 20 mm. long. Toward the distal ends of the costals the pits increase in size. On the distal fourth of the costals the pits are arranged in longitudinal rows, with broad ridges between the rows. In some places there are only three or four rows in a 20 mm. line. On the rear of the carapace the pits are of size larger than the average.

All portions of the plastron (Fig. 10) are present. The entoplastron has the usual V-shape, with the limbs each 112 mm. long. The epiplastra are 18

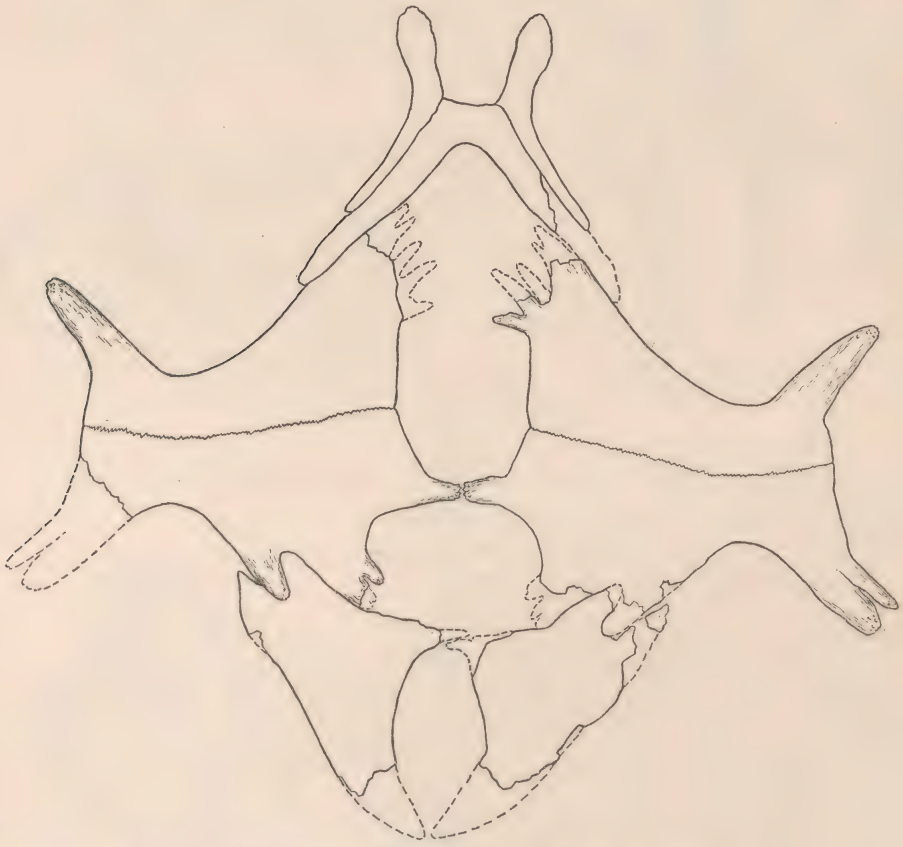

Fig. 10. *Aspideretes singularis* Hay. Plastron of type. × ¼.

mm. broad in front, pointed behind, and about 100 mm. long. The bridge has a width of 56 mm. equally divided between the hyoplastron and the hypoplastron. The whole extent of the inner border of the hyoplastron and the hypoplastron taken together is at least 175 mm. The xiphiplastron is of triangular form, with the proximal processes interdigitated with the processes of the hypoplastron. Each is about 110 mm. long and 75 mm. wide. With the exception of the anterior and posterior processes the whole lower surface of each xiphiplastron is sculptured.

The sculpture of the plastron is less prominent than that of the carapace. It consists of vermicular ridges occasionally anastomosing and enclosing pits and furrows. Toward the midline the ridges are inconspicuous.

The skull is nearly complete and is but little distorted. Some of the distortion has been corrected in the figure. The skull resembles closely that of *Platypeltis ferox*, but the profile descends more abruptly from the middle of the orbits.

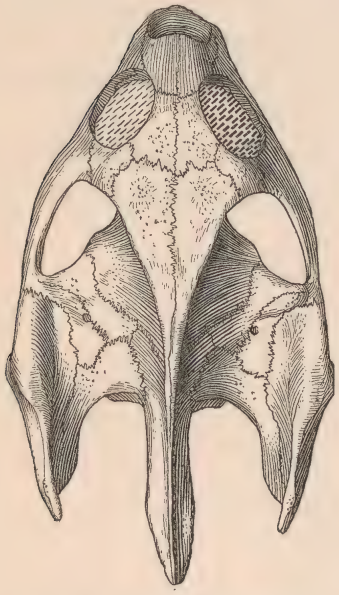

Fig. 11. *Aspideretes singularis* Hay. Skull of type seen from above. × ½

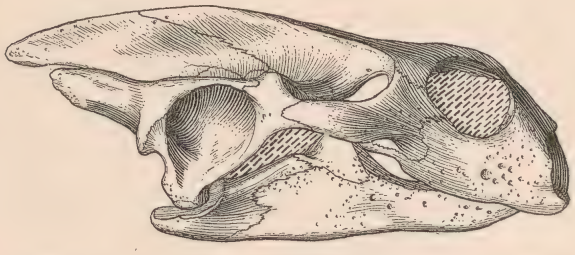

Fig. 12. *Aspideretes singularis* Hay. Skull of type seen from right side. × ½.

The length from the snout to the occipital condyle (Fig. 11) is 102 mm.; to the extremity of the supraoccipital spine, 131 mm. From the outside of one quadrate to the other is 67 mm. The nasal opening is 16 mm. wide. The orbits are much larger than those of *Platypeltis ferox*, each of the diameters being 20 mm. The interorbital space is 10 mm. wide. The postorbital bar (Fig. 12) has a width of 9 mm. The distance from the orbit to the front of the auditory chamber is 40 mm. The latter has a horizontal diameter of 21 mm.

The roof of the mouth (Fig. 13) is almost wholly concealed by the lower jaw and the bones of the tongue. It is seen, however, that the front of each choana is placed 25 mm. behind the tip of the snout. Nothing can be determined regarding the nature of the triturating surfaces of the jaws.

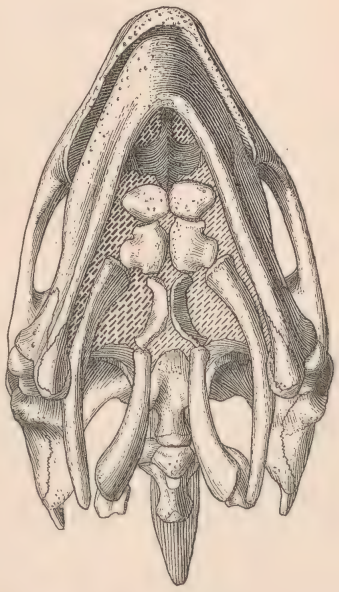

Fig. 13. *Aspideretes singularis* Hay. Skull of type seen from below. × ½.

The length of the lower jaw from the front to the angle is 84 mm. The length of the symphysis is 17 mm. The height of the jaw at the coronoid is 28 mm.

The hyoid bones are completely preserved, except, perhaps, the ceratohyals; but these small bones may yet be buried in the matrix. There are present a pair of basihyals and two pairs of basibranchials. The more anterior basibranchials are each 72 mm. long; those of the hinder pair, 37 mm. long.

The atlas has the structure found in *Platypeltis*. The two pieces of the neural arch and the hypocentrum form the cup receiving the occipital condyle. Behind these bones comes the true centrum, or odontoid bone.

The body of the scapula (Fig. 14) is 130 mm. long, including the glenoid cavity. The maximum diameter of this cavity is 33 mm. The procoracoid process is 86 mm. long. It expands distally to a width of 32 mm. The coracoid is 137 mm. long, measuring from the glenoid cavity. From its base it expands rapidly to a width of about 35 mm.

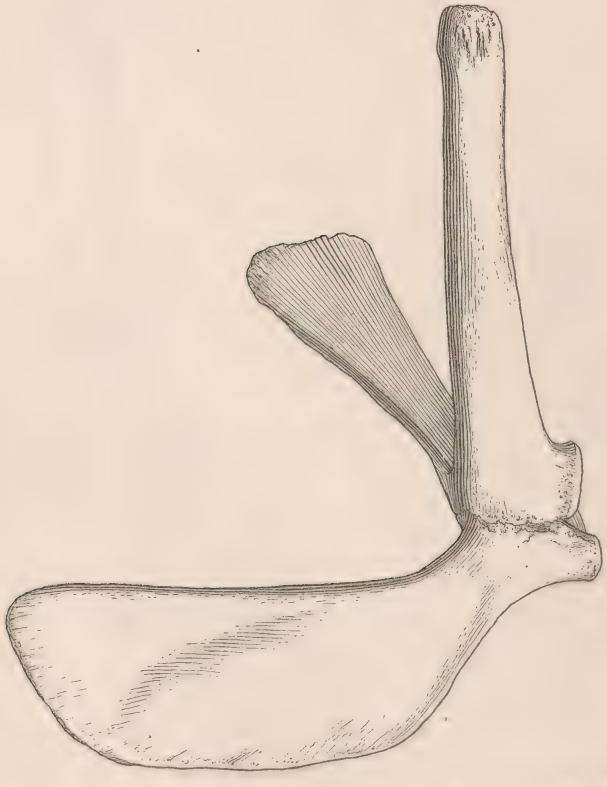

Fig. 14. *Aspideretes singularis* Hay. Right scapula and coracoid of type. × ½.

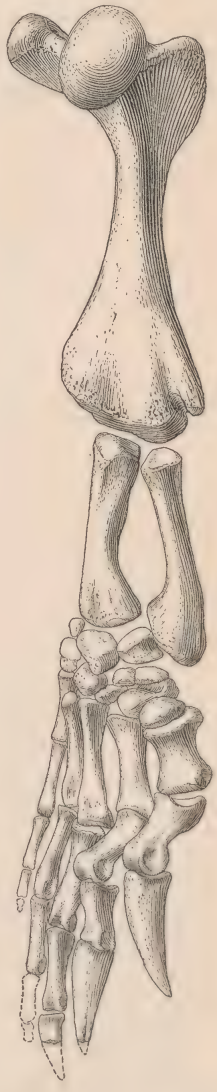

Fig. 15. *Aspideretes singularis* Hay. Right fore leg of type, dorsal surface. × ½.

The length of the humerus (Fig. 15), from the proximal surface of the head to the distal end, is 101 mm. The least diameter of the shaft is 12 mm. The width of the distal end is 36 mm. The ulna is 43 mm. long, being relatively shorter, when compared with the humerus, than the same bone in *Platypeltis spinifera.* The radius is 49 mm. long. The bones of the carpus are as in the modern members of the family, there being *radiale, ulnare, intermedium, pisiforme, centrale,* and five distal carpals. The length of the first digit is 68 mm. Only the first and the second phalanges of the fourth digit are preserved, so that it is impossible to say whether or not there were more than three altogether. Of the fifth digit there are present three phalanges, and there was probably a fourth.

The pelvis (Fig. 16) resembles closely that of the

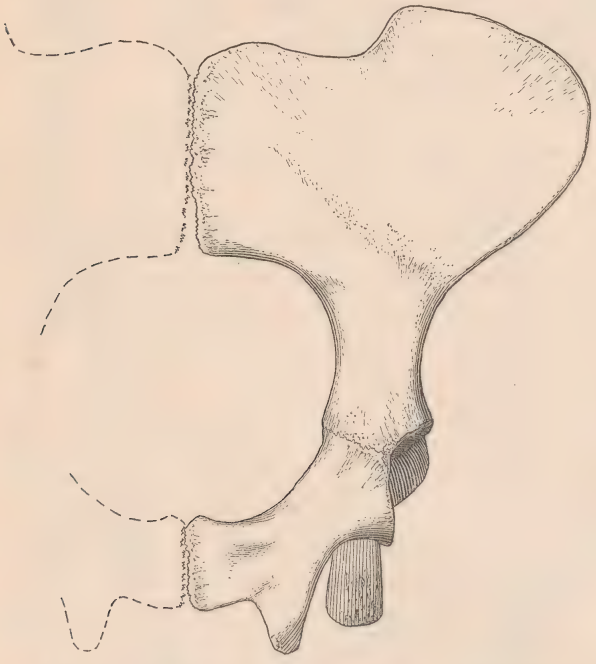

Fig. 16. *Aspideretes singularis* Hay. Pelvis of type, seen from below. × ½.

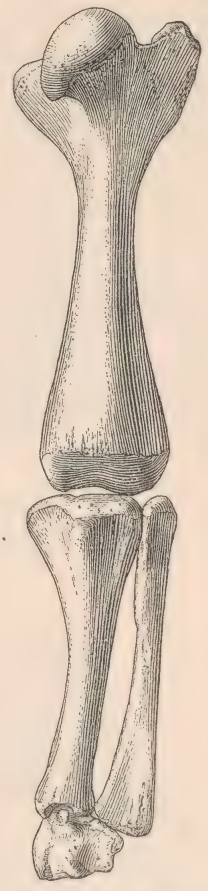

Fig. 17. *Aspideretes singularis* Hay. Left hind leg of type, dorsal surface. Shows femur, tibia, fibula, and astragalo-calcaneum. × ½.

living species of trionychid mentioned above. The height of the acetabulum is two-thirds its length, being thus higher than in *Platypeltis.* Each pubis has a width of 88 mm. and is notched in front.

The femur (Fig. 17) has a length of 113 mm. The head is oval, the shaft has a minimum diameter of 12 mm. and the distal end is 32 mm. wide. The tibia has an extreme length of 75 mm.; the fibula, 78 mm. The bones

of the ankle do not differ in form or structure from those of living forms of the family. Only the bases of the metatarsals have been preserved. They present nothing worthy of record.

Platypeltis antiqua sp. nov.

Fig. 18.

The Cope collection of fossil reptiles has recently afforded a specimen of trionychid to which the above name is given. This specimen, No. 1036 of the American Museum of Natural History, appears to have been collected by Mr. D. Baldwin, in 1883, in probably San Juan County, New Mexico. It was derived from Torrejon deposits. It presents wholes or portions of the costals of five pairs, five neural bones, some limb bones, and apparently

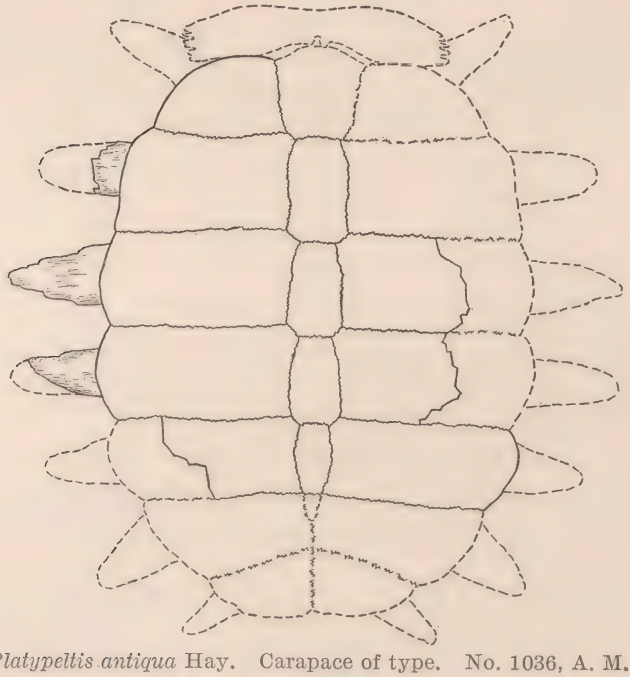

Fig. 18. *Platypeltis antiqua* Hay. Carapace of type. No. 1036, A. M. N. H. × ⅔.

a portion of the plastron. The limbs and the plastral bones are imbedded in such a hard matrix that no attempt has been made to remove it. In the text-figure (Fig. 18) restored portions are enclosed by interrupted lines.

The most anterior piece of bone is regarded as the left first costal. It is 20 mm. long from side to side, 13 mm. fore and aft. Its outer and anterior borders are smooth and the anterior was not articulated suturally with any bone in front. That this bone was not the nuchal appears to be

shown by the fact that the inner anterior angle of the next bone behind is truncated, as if by a neural in front of its own. Moreover, the mesial border of the bone in question is a sutural border for union with a neural. Having no jagged sutural border in front it can not be the second costal. It is therefore evidently the first costal. The nuchal is missing and must have been, as in *P. serialis,* only loosely joined to the first neural and costals. It is restored from that of *Platypeltis spinifera.*

The line stretching across the five costals present on the left side is 75 mm. long. The length of the carapace was therefore about 100 mm. The width of the disk was 78 mm.; but the ribs extended beyond this at least 18 mm. Evidently the carapace was relatively shorter and broader than that of *P. serialis.*

That there were only seven pairs of costals is concluded from the fact that the outer border of the fifth costal is directed so strongly inward that the seventh costal must have been very short, leaving no room for the eighth costals.

The hinder portion of the first neural is present. There is no trace of a preneural. Therefore, the genus *Platypeltis* is indicated. The following are the dimensions (in millimeters) of the neurals measurable:

Neural	Length	Width
2	14	10
3	16	9
4	15	8
5	12	6

It is probable that the first neural was not so wide as it is represented in the figure. It it also probable that there was a small sixth neural. The neurals are from 2.5 mm. to 3 mm. thick.

The surface of the carapace presents no welts, but is everywhere pitted. Of the pits there are, at the proximal ends of the costals and on the neurals, six in a line 10 mm. long; on the outer ends of the costals, five in a line 10 mm. long.

This species differs from *P. serialis,* of the Wasatch and Bridger, in having no welts on the upper surface and in having smaller pits. From *P. trionychoides* of the Bridger, it differs in having coarser pits, as well as in other respects.

Platypeltis amnicola sp. nov.

PLATE LIV, FIGS. 5, 6, AND TEXT-FIG. 19.

This specific name is applied to an incomplete and fragmentary shell which was collected in 1906 by the American Museum's expedition into the Wasatch beds of southwestern Wyoming. The specimen consists of two

neurals and a part of a third, enough fragments to constitute apparently nearly the whole of the costals, but which have not yet been put together, most of the hyoplastron and hypoplastron of the left side, and the inner ends of those of the right side. The specimen was found on Bitter Creek and has the catalogue number 6044.

The carapace had apparently a length of about 280 mm., and a width of about 200 mm.; but the ratio of the width to the length may have been greater. The costals resemble in thickness and sculpture those of *Platypeltis heteroglypta*, and it is possible but not probable that the individual belongs to that species. However, the thickness of the costals, at the outer ends at least, appears to be less, being 5 mm. or less at the sutural border,

Fig. 19. *Platypeltis amnicola* Hay. Left hyoplastron and hypoplastron of type. No. 6044, A. M. N. H. Partly restored. × ½.

from 7 mm. to 9 mm. through the rib. At the neural border the thickness is 7 mm. One costal is 46 mm. wide at the distal end; another, apparently the right fifth (Plate LIV, Fig. 6), is 41 mm. wide distally. The left sixth is 36 mm. wide distally. The right eighth is present, slightly damaged. Evidently it was enclosed in a notch in the seventh. It is 25 mm. long, fore and aft; the width was slightly greater. The free borders of the costals are beveled off obliquely. What is regarded as the third neural (Plate LIV, Fig. 5) has a length of 36 mm., a width of 25 mm. at the hinder end, and a thickness of 6 mm.

The sculpture consists of pits surrounded by walls with rounded summits. Near the free borders of the shell (Plate LIV, Fig. 6) the pits are arranged

somewhat in rows parallel with the border. Toward the proximal ends of the costals the pits become larger, apparently by the coalescence of the smaller pits. Of the smaller pits there are six or seven in a line 20 mm. long. The pits near the neural borders of the costals and on the neurals (Plate LIV, Fig. 5) may be two or three times as large, and are arranged irregularly.

What appears to be the right outer end of the nuchal is present. Differently from *P. heteroglypta,* the sculptured layer seems to have extended to the end of the bone.

Of the left hyoplastron and hypoplastron a portion across the bridge is missing. The length of the suture between the two bones appears to have been about 120 mm. Where narrowest the bridge was 45 mm. wide, and here the bones are about 13 mm. in thickness. Of the width of the bridge the hyoplastron occupies 20 mm. The notch for the xiphiplastron is missing but it could have had little depth.

The whole lower surface of these plastral bones, except the processes, is covered with pits and ridges. The pits are considerably smaller than those of the carapace, there being usually five in a line 10 mm. long.

Platypeltis trepida sp. nov.

PLATE LIV, FIG. 7, AND TEXT-FIG. 20.

The type of the present species was found in the year 1905, by a member of the American Museum's expedition into the Bridger beds of Wyoming. The locality at which it was secured is Grizzly Buttes; the level is that designated as B, 2. The catalogue number of the specimen is 5925.

The nuchal bone of the specimen is wanting, as well as large parts of the costals of the right side, and all the neurals except the fourth and the fifth. On the left side most of the sixth costal and all of the seventh are wanting. In the figure those bones and parts of bones present are enclosed by solid lines; the restored parts by interrupted lines.

The individual (Fig. 20) was a small one, the total length having originally been about 100 mm. The distance from the anterior border of the first costal to the hinder border of the fifth at its outer end is 77 mm. The breadth of the disk is 92 mm. Beyond the free border the ribs extended at least 15 mm.

The fourth neural is 11 mm. long and 9 mm. wide; the fifth is 10 mm. long and 8 mm. wide. Each of these has a low but distinct median keel. The costals are thin, the thickness being 2 mm. or less. The first is 16 mm. wide; the second is 12 mm. wide at the proximal end. The anterior border of the first shows that it was united to the nuchal bone by a jagged suture.

The costals are traversed by a number of longitudinal ridges which are

but little more conspicuous than the other ridges between the pits. The pits are mostly in rows parallel with the more conspicuous ridges. Of the pits there are from five to seven in a line 10 mm. long. Those on the outer ends of the costals are somewhat the larger.

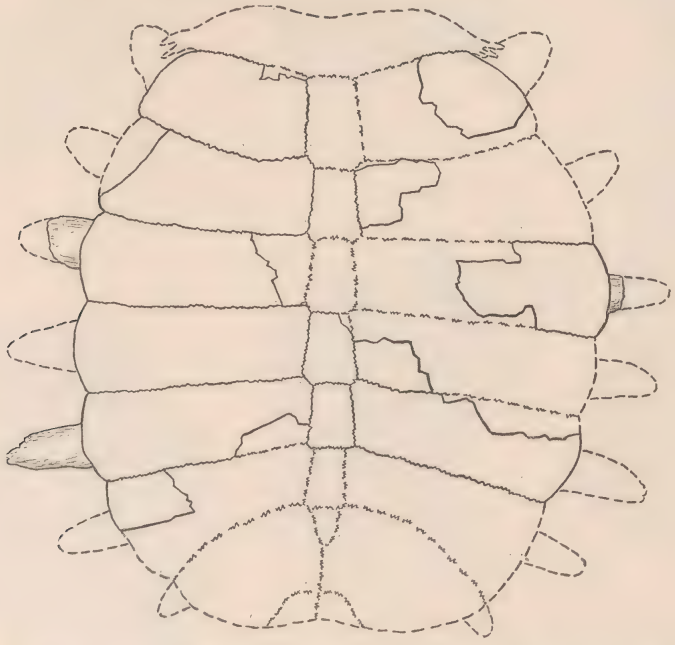

Fig. 20. *Platypeltis trepida* Hay. Carapace of type. No. 5925, A. M. N. H. Partly restored. × ⅔.

This species differs from the specimens referred to *Platypeltis serialis* (*Plastomenus serialis* Cope) in the closer union of the nuchal and first costal, in the presence of a keel on at least some of the neurals, and in the finer sculpture of the carapace.

EXPLANATION OF PLATE LIV.

All of the figures are of the size of nature and are presented to illustrate the details of the sculpture.

Figs. 1–3. *Plastomenus acupictus* Hay.
- Fig. 1. Portions of two anterior costal bones.
- Fig. 2. Portion of sixth and whole of seventh left costals.
- Fig. 3. Left hypoplastron and xiphiplastron.

Fig. 4. *Aspideretes singularis* Hay. Distal end of fourth left costal.

Figs. 5, 6. *Platypeltis amnicola* Hay.
- Fig. 5. Supposed third neural, with contiguous ends of costals.
- Fig. 6. Supposed right fifth costal.

Fig. 7. *Platypeltis trepida* Hay. Median and left portions of the carapace.

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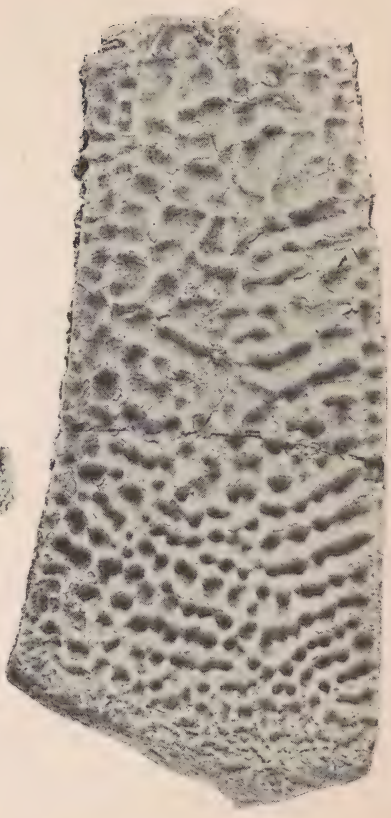

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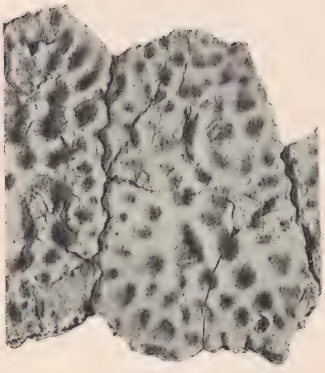

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Fossil Turtles.

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Article XXXV.— REVISION OF THE MIOCENE AND PLIOCENE EQUIDÆ OF NORTH AMERICA.

By James Williams Gidley.

With an introductory Note by Henry Fairfield Osborn.

Introductory Note.

The American Museum collection of Horses — from the Eocene to the Pleistocene inclusive — now numbers several thousand specimens, including nearly fifty types and about as many casts of types. It is desired gradually, as opportunity permits, to make this type collection absolutely complete either through originals or casts.

The first step towards a thorough understanding of the Equidæ is a systematic revision of all the generic and specific names which have been proposed, and of the characters of the valid genera and species, starting with an exact study and comparison of the type specimens. As planned this is being done by coöperation of the writer, of Mr. Walter Granger of the American Museum staff, and especially of Mr. J. W. Gidley, formerly of this Museum, now of the United States National Museum, and the author of the present paper, who has made a specialty of the horse from the Oligocene to the Pleistocene inclusive.

The list of these revisions, as completed or in progress, is as follows:

Pleistocene.

Tooth Characters and Revision of the North American Species of the Genus Equus. By J. W. Gidley. Bull. Am. Mus. Nat. Hist., Vol. XIV, 1901, pp. 91–141, pll. xvii–xxi, and 27 text figures.

Miocene and Pliocene.

Proper Generic Names of Miocene Horses. By J. W. Gidley. Bull. Amer. Mus. Nat. Hist., Vol. XX, 1904, pp. 191–194.

Revision of the Miocene and Pliocene Horses of North America. By J. W. Gidley. Bull. Amer. Mus. Nat. Hist., Vol. XXIII, 1907, pp. 865–932.

Oligocene of the White River.

New Oligocene Horses. By H. F. Osborn. Bull. Amer. Mus. Nat. Hist., Vol. XX, 1904, pp. 167–179, pll. iv and v, and 8 text figures.

Eocene.

North American Eocene Horses. (In Preparation.) By Walter Granger.

In order to spread the more exact knowledge of the American Horses — and to make our own collection more comprehensive — the Museum has made a series of casts of the skulls, teeth and feet, of typical specimens which are to be used in exchange for similar casts, or preferably original duplicates, from other Museums. As soon as the monograph on the Equidæ is completed the Museum will also be ready to exchange a large part of its original duplicate collection, but for the present it is desirable to retain all such specimens for the purpose of comparative study of growth changes and variations.— H. F. O.

Introduction.

This revision has necessitated not only a restudy and comparison of all the available types, representing upwards of fifty proposed species, but a systematic and exhaustive study of all other available horse material from the American Miocene and Pliocene deposits. The great amount of more complete and better collected specimens, obtained by the expeditions of later years, especially those of the American Museum made possible through the generosity of the late William C. Whitney, has been a large factor in clearing up many points regarding the determination and classification of species.

I wish here to acknowledge my indebtedness to Prof. Henry F. Osborn for placing this material in my hands for revision, and my especial appreciation of his valuable aid and that of Dr. W. D. Matthew in systematically laying out the work, and for their many helpful suggestions and kindly criticism.

At the beginning of this work it was found that, as in the case of the North American species of the genus *Equus*,[1] our knowledge of the Miocene and Pliocene horses has been obtained largely from material of a most fragmentary nature, in many instances consisting of single isolated teeth. In consequence there has been on the part of early writers a very limited understanding even of fundamental characters regarding the general tooth structure of horses. The effects of age-wear and the limits of individual variation have often not been taken sufficiently into account, and in many cases investigators have failed to distinguish between the deciduous and

[1] Tooth Characters and Revision of the North American Species of *Equus*. Bull. Amer. Mus. Nat. Hist., Vol. XVI, 1901, pp. 91–142.

permanent dentitions. These causes have frequently led to confusion in determining both genera and species, and has resulted in errors of classification.

One of the important results of this study has been to show the necessity of a partial rearrangement of the Equidæ as a whole. The species of the family may now be grouped provisionally under four distinct subfamilies, as defined below.

I. Provisional Arrangement of the North American Equidæ.

Horses with Four Toes and Short-crowned Teeth. Eocene.

I. **Hyracotheriinæ** Cope. Teeth brachyodont; molariform premolars not more than two; digit formula 4–3; rudimentary fifth digit on hind foot; 1st digit of fore foot not represented in known forms. Orbit not closed behind.

This subfamily includes all the known Eocene genera of horses.

Horses with Three Toes and Short-crowned Teeth. Oligocene, Miocene.

II. **Anchitheriinæ** Leidy. Teeth brachyodont; molariform premolars three; digit formula 3–3; 5th digit on fore foot vestigial; 1st digit of fore foot not represented in known forms; lateral toes, so far as known, reaching the ground; orbit not closed behind.

A. *Inner cones (pr and hy) larger than median conules (pl and ml); protocone occupying more than one half the transverse diameter of the crown; prefossette continuous with inner median valley; no anterior median fold of metaloph (crochet).*

1. Metaloph not united with ectoloph; protoconule distinct, coniform; m_1 and p_4 largest of lower series. The points of greatest transverse width are the anterior half of m_1 and posterior half of p_4 . . . . . *Mesohippus.*

2. Metaloph completely united with the ectoloph; protoconule distinct, coniform; p_3 and p_4 largest of lower series, subequal in transverse width. *Anchitherium.*

3. Metaloph completely united with ectoloph; protoconule and metaconule nearly or quite lost in the continuous transverse lophs; m_1 and p_4 largest of the lower series, subequal in transverse width; metastylid undeveloped, or but slightly separated from the metaconid . . . . . *Hypohippus.*

B. *Inner cones (pr and hy) larger than median conules (pl and ml); protocone occupying less than one half the transverse diameter of the crown; metaloph completely united with the ectoloph; protoconule distinct, coniform.*

4. Prefossette partially inclosed by a well defined anterior median fold (crochet) of the metaloph; p_4 and p_3 largest of the lower series, subequal in transverse width; metastylid separated more or less distinctly from the metaconid . . . . . *Parahippus.*

5. Metaloph without anterior median fold; prefossette continuous with inner median valley; p_4 probably not larger than m_1 as indicated by the comparatively large upper true molars . . . . . *Archæohippus.*

C. *Inner conules (pr and hy) smaller than median conules (pl and ml) protoconule semi-crescentic; partially or completely united with the metaloph; orbit completely inclosed; digits of fore foot all represented, but with 1st and 5th vestigial.*

"C" includes hypothetical genera, not as yet discovered, more directly ancestral to the Protohippinæ.

Horses with Three Toes and Long-crowned Teeth. Miocene.

III. **Protohippinæ**[1] nom. nov. Teeth hypsodont; cement a functional part of the tooth crown, at least in the adult series; digit formula 3–3; lateral digits (2d and 4th) not reaching the ground so far as known; 1st and 5th digits of fore foot present but vestigial, being represented by nodules of bone in all known forms; orbit closed behind.

Additional characters are: protoconule and metaconule large, crescentic in outline and completely inclosing the pre- and post-fossettes respectively; protocone and hypocone smaller than median conules (pl and ml); metaconid and metastylid subequal and completely divided internally by a continuous groove.

A. *Milk molars brachyodont to subhypsodont, with little or no cement; permanent molars short-hypsodont, height of crowns about equaling their anteroposterior diameters; cheek teeth heavily cemented, with cement a functional part of the crown.*

1. Protocone free to completely united with protoconule; lachrymal fossæ shallow to well defined; malar fossæ well defined to wanting . *Merychippus.*

B. *Milk and permanent molars hypsodont, well cemented; protocone completely united with protoconule; molar crowns not more than twice the length of their anteroposterior diameters; crowns of upper molars moderately curved; fossettes broad transversely, with open external loops and simple enamel foldings; inner wall of protoconule flat to concave; lateral toes much reduced, probably not functional.*

2. Lachrymal fossa shallow, borders not sharply defined; malar fossa shallow or wanting . . . . . *Protohippus.*

3. Lachrymal and malar fossæ large and partially confluent, with posterior borders sharply defined . . . . . *Pliohippus.*

4. Characters like those of 3, except that the protocone and hypocone are partially to completely united. . . . . *Protohippus or Pliohippus.*

C. *Both milk and permanent molars hypsodont and well cemented; protocone free from protoconule except at base; molar crowns more than twice the length of their anteroposterior diameters; crowns of upper molars comparatively straight; inner wall of protoconule flat to convex, giving a transversely compressed appearance to the prefossette.*

5. Enamel foldings of fossette borders complex; protocone comparatively

[1] **Protohippinæ** replaces Hippotheriinæ Cope, which can no longer be imployed since the genus name *Hippotherium* is antedated by *Hipparion.*

small, and more or less circular in cross-section; lachrymal fossa large and infolded into a well defined pit posteriorly; malar fossa shallow or wanting; lateral toes large . . . . . *Hipparion.*

6. Enamel foldings of fossette borders comparatively simple; protocone comparatively large, and laterally compressed; lachrymal fossa shallow, borders not sharply defined; malar fossa shallow or wanting; lower border of mandibular rami deeply bowed; lateral toes much reduced. . *Neohipparion.*

D. *So far as known, species diminutive as compared with those of* 2, 3, 4, *and* 6 *of B and C. Milk and permanent molars hypsodont, well cemented; molar crowns more than twice the length of their anteroposterior diameters; upper molar crowns comparatively straight; so far as known, lachrymal fossa comparatively small and shallow; malar fossa shallow or wanting; so far as known, lateral toes much reduced.*

2*a*. Protocone completely united with protoconule to summit; fossettes with simple enamel borders; lower borders of mandibular rami nearly straight. *Protohippus placidus.*

6*a*. Protocone free or partially free from protoconule except at base; fossettes with moderately complex enamel borders; lower border of mandibular rami deeply bowed . . . . . *Neohipparion gratum.*

Horses with One Toe and Long-crowned Teeth. Pliocene, Pleistocene and Recent.

IV. **Equinæ** Osborn. Tooth crowns hypsodont; cement a functional part of the teeth; digit formula 1–1; 1st and 5th digits wanting; 2d and 4th digits represented by "splints"; bicipital groove of humerus double; orbit closed behind.

A. *Limbs short; tooth crowns short hypsodont, upper molars deeply curved.*

1. Molar crowns less than twice the height of their anteroposterior diameters; upper molars with protocone small and cylindric, but united with protoconule to summit . . . . . *Hippidion.*

B. *Limbs long; tooth crowns long; upper molars straight or but slightly curved.*

2. Molars more than twice the length of their anteroposterior diameter; upper molars with protocone large, laterally compressed and united with protoconule to summit . . . . . *Equus.*

In tooth characters *Hippidion* has more the affinities of group B of the Protohippinae.

While phylogeny has by no means been ignored, the above grouping and definition of the subdivisions of the Equidæ are founded on a basis of structural affinities rather than on phylogenetic relations.

Thus, while the four subfamilies undoubtedly represent as many successive stages in the evolution of the horse, forms directly ancestral to the known genera of the later groups probably are not represented by known genera of the same or earlier groups. It is moreover evident, from a study of the abundant material at hand, that although the general lines of progressive development are clearly indicated and several distinct lines of subphyla

suggested, the direct lines of descent are by no means complete and the known genera cannot at present be arranged in any permanent phyletic series.

It is further indicated that the different genera of horses hitherto proposed may or may not represent groups of closely allied species, hence it is difficult in many instances to positively refer a species to its proper genus owing to the overlapping and apparent intermixing of characters to which generic values have been given.

It will be noted that the morphological distinctions between the two intermediate groups, the Anchitheriinæ and Protohippinæ of the above arrangement, are very clearly marked, indicating a considerable phyletic hiatus which is not bridged over by any species thus far discovered. This may be considered sufficient ground for dividing the great group into two distinct families, as has been done by Gill.[1] However, I prefer for the present to hold the above arrangement, filling in the gap with the hypothetical group defined under division C. of the Anchitheriinæ.

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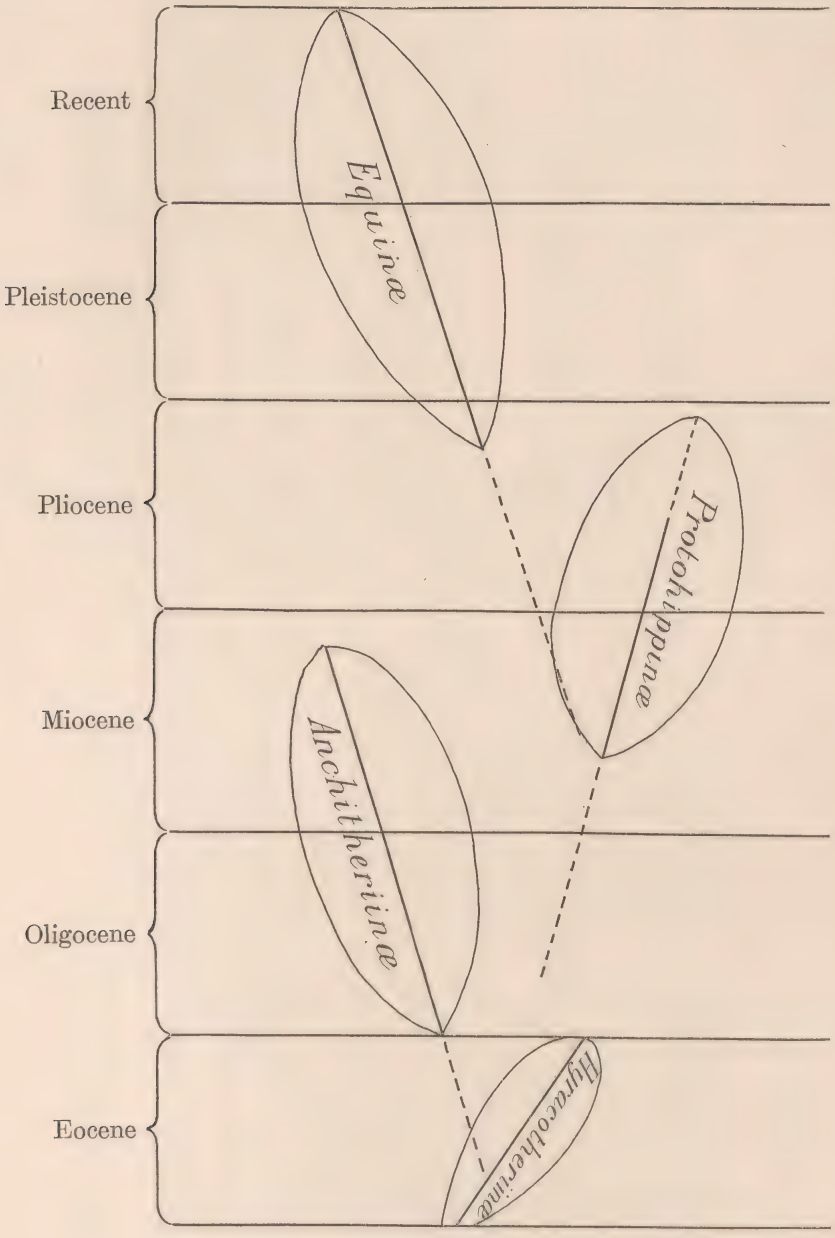
[1] Arrangement of Families of Mammals, Theodore Gill, 1872, p. 104. Smithsonian Miscellaneous Collection, Vol. XI, 1874, p. 84.

The probable relations of the four subfamilies as above defined are suggested in the following diagram.



Chronological Table of Proposed Genera and Species of Miocene Horses Reported from North America.

No.	Date	Name and Author	Locality	Type first figured	Collection containing type
1	1854	*Hippodon speciosus* Leidy	Bijou Hill, S. D.	Not figured	Not located.
2	1856 (Feb.)	*Hipparion occidentale* Leidy	Little White River (Neb.) So. Dakota	Ext. Mam. Fauna Dak. & Neb., 1869, pl. xviii, figs. 1 to 5	Acad. Nat. Sci. Phila.
3	1856 (Dec.)	*Merychippus insignis* Leidy	Bijou Hill, S. D.	Ext. Mam. Fauna, Dak. & Neb., 1869, pl. xvii, figs. 3 and 4	Acad. Nat. Sci. Phila.
4 (1)	1856 (Dec.)	*Hipparion* (*Hippodon*) *speciosus* Leidy	Bijou Hill, S. D.	Not figured	Acad. Nat. Sci. Phila.
5	1858	*Anchitherium* (*Hypohippus*) *affinis* Leidy	Fort Niobrara, Niobrara River, Nebraska	Ext. Mam. Fauna, Dak. & Neb., pl. xxi, figs. 11, 12	No. 573, National Museum, Washington.
6	1858	*Anchitherium* (*Parahippus*) *cognatus* Leidy	Fort Niobrara, Niobrara River, Nebraska	Ext. Mam. Fauna, pl. xxi fig. 7	No. 576, National Museum, Washington.
7	1858	*Equus* (*Protohippus*) *perditus* Leidy	Fort Niobrara, Niobrara River, Nebraska	Ext. Mam. Fauna, pl. xvii, figs. 1, 2	No. 619, National Museum, Washington.
8	1858	*Merychippus mirabilis* Leidy	Fort Niobrara, Niobrara River, Nebraska	Ext. Mam. Fauna, pl. xvii, figs. 10, 11	No. 570 National Museum, Washington.
9	1860	*Hippotherium venustum* Leidy	Ashley River, So. Carolina	Holmes' Post-pli. Fossils, S. C., pl. xvi, fig. 33	Not located.
10	1868	*Equus parvulus* Marsh (*Protohippus parvulus* Marsh, 1874)	Antelope Springs, Nebraska	Not figured	Yale Museum.
11	1868	*Anchippus texanus* Leidy	Washington Co., Texas	Ext. Mam. Fauna, pl. xxi, figs.	Acad. Nat. Sci. Phila.

No.	Date	Name and Author	Locality	Type first figured	Collection containing type.
12	1869	*Protohippus placidus* Leidy	Fort Niobrara, Niobrara River, Nebraska	Ext. Mam. Fauna, pl. xviii, fig. 40	Acad. Nat. Sci. Phila.
13	1869	*Hipparion affine* Leidy	Fort Niobrara, Niobrara River, Nebraska	Ext. Mam. Fauna, pl. xviii, figs. 20–24	National Museum, Washington.
14	1869	*Hipparion gratum* Leidy	Fort Niobrara, Niobrara River, Nebraska	Ext. Mam. Fauna, pl. xviii, fig. 25	National Museum, Washington.
15	1869	*Protohippus supremus* Leidy	Little White River, South Dakota	Ext. Mam. Fauna, pl. xxvii, fig. 4	Acad. Nat. Sci. Phila.
16	1874	*Hippotherium paniense* Cope	Pawnee Buttes, Colorado	Proc. Am. Phil. Soc., p. 458, figs. 13, 14	Amer. Mus. Nat. Hist.
17	1874	*Protohippus labrosus* Cope	Pawnee Buttes, Colorado	Not figured	
18	1874	*Protohippus sejunctus* Cope	Pawnee Buttes, Colorado	Not figured	Amer. Mus. Nat. Hist.
19	1874	*Pliohippus pernix* Marsh	Fort Niobrara, Niobrara River, Nebraska	Not figured	Yale Museum.
20	1874	*Pliohippus robustus* Marsh	Fort Niobrara, Niobrara River, Nebraska	Not figured	Yale Museum.
21	1874	*Protohippus avus* Marsh	Cottonwood Creek, Oregon	Not figured	Yale Museum.
22	1874	*Anchippus brevidens* Marsh	Cottonwood Creek, Oregon	Not figured	Yale Museum.
23	1875	*Hippotherium calamarium* Cope	Near San Ildefonso, New Mexico	U. S. Geol. Surv. west of 100th M., 1877, IV, pl. lxxv, fig. 1.	National Museum, Washington.
24	1878	*Stylonus seversus* Cope	Cottonwood Creek, Oregon	Proc. Am. Phil. Soc., 1889, p. 458, fig. 24	Amer. Mus. Nat. Hist.
25	1880	*Hippidium spectans* Cope	Cottonwood Creek, Oregon	Am. Nat., 1887, p. 1072, fig. 41	Amer. Mus. Nat. Hist.

No.	Date	Name and Author	Locality	Type first figured	Collection containing type
26	1882	*Hippotherium montezumæ* Leidy	Hidalgo, Mexico	Proc. Acad. Nat. Sci., 1882, p. 291, fig.	National Museum, Washington.
27	1882	*Hippotherium sinclarii* Wortman	Cottonwood Creek, Oregon	Proc. Amer. Phil. Soc., 1886, p. 458, fig. 2	Amer. Mus. Nat. Hist.
28	1885	*Hippotherium peninsulatum* Cope	Vera Cruz, Mexico	Am. Nat., Vol. xix, pl. 28, fig. 5	Amer. Mus. Nat. Hist.
29	1885	*Protohippus castilli* Cope	Vera Cruz, Mexico	Am. Nat., Vol. xix, pl. 28, fig. 6	Not located.
30	1885	*Hippotherium ingenuum* Leidy	Archer, Fla.	Proc. Acad. Nat. Sci., 1885, p. 33	National Museum, Washington.
31	1886	*Anchitherium ultimum* Cope	Cottonwood Creek, Oregon	Bull. Amer. Mus. Nat. Hist., 1905	Amer. Mus. Nat. Hist.
32	1887	*Hippotherium rectidens* Cope	Vera Cruz, Mexico	Proc. Am. Phil. Soc., 1889, p. 458, fig. 3	Not known.
33	1887	*Hipparion plicatile* Leidy	Archer, Fla.	Proc. Acad. Nat. Sci., 1887, p. 310	National Museum, Washington.
34	1889	*Hippotherium relictum* Cope	Oregon Desert	Proc. Am. Phil. Soc., 1889, p. 458, fig. 19	Amer. Mus. Nat. Hist.
35	1889	*Hippotherium retrusum* Cope	Philips Co., Kan.	Proc. Am. Phil. Soc., 1889, p. 458, figs. 7 and 8	Amer. Mus. Nat. Hist.
36	1889	*Protohippus* or *Hippidium profectus* Cope	Philips Co., Kan.	Proc. Am. Phil. Soc., 1889, p. 458, figs. 9 to 12	Amer. Mus. Nat. Hist.
37	1889	*Hippotherium sphenodus* Cope	Pawnee Buttes, Colorado	Proc. Am. Phil. Soc., 1889, p. 458, figs. 21, 22	Amer. Mus. Nat. Hist.
38	1889	*Hippotherium isonesum* Cope	Cottonwood Creek, Oregon	Proc. Am. Phil. Soc., 1889, p. 458, fig. 23	Amer. Mus. Nat. Hist.

No.	Date	Name and Author	Locality	Type first figured	Collection containing type
39	1890	*Hippotherium princeps* Leidy	Peace Creek, Florida	Proc. Acad. Nat. Sci., p. 182, fig.	National Museum, Washington.
40	1892	*Pliohippus gracilis* Marsh	Oregon	Not figured	Yale Museum.
41	1892	*Equus simplicidens* Cope	Mt. Blanco, Crosby Co.,Tex.	Proc. Am. Phil. Soc., 1892, p. 124, fig. 1	University of Texas.
42	1892	*Protohippus pachyops* Cope	Donley Co., Tex.	Rep. Tex. Geol. Surv., 1893, pl. xi, fig. 1	University of Texas.
43	1893 (May)	*Protohippus fossulatus* Cope	Donley Co., Tex.	Rep. Tex. Geol. Surv., 1893, pls. v, vi, vii	University of Texas.
44	1893	*Protohippus lenticularis* Cope	Mulberry Cañon, Goodnight Texas	Rep. Tex. Geol. Surv., 1893, pl. xii, figs. 1, 2	University of Texas.
45	1893	*Hippidium interpolatum* Cope	Mulberry Cañon, Goodnight Texas	Rep. Tex. Geol. Surv., 1893, pl. xii, figs. 3, 4	University of Texas (?)
46	1893	*Equus curvistylus* Cope	Paloduro Cañon, Texas	Rep. Tex. Geol. Surv., 1893, pl. xx, fig. 6	University of Texas (?)
47	1893	*Equus cumminsii* Cope	Mt. Blanco, Texas	Rep. Tex. Geol. Surv., 1893, pl. xx, fig. 7	University of Texas (?)
48	1893	*Equus minutus* Cope	Mt. Blanco, Texas	Rep. Tex. Geol. Surv., 1893, pl. xx, fig. 8	University of Texas (?)
	1899	*Equus phlegon* Hay	(to replace *E. minutus* Cope, preoccupied)		
49	1893 (July)	*Desmatippus crenidens* Scott	Deep River, Montana	Trans. Am. Phil. Soc., 1893, pl. ii, figs. 9–14	Princeton University.
50	1893 (July)	*Anchitherium equinum* Scott	Deep River, Montana	Trans. Am. Phil. Soc., 1893, pl. iii, figs. 23–28	Princeton University.

No.	Date	Name and Author	Locality	Type first figured	Collection containing type
52	1903	*Neohipparion whitneyi* Gidley	Little White River, S. D.	Not figured	Amer. Mus. Nat. Hist.
53	1906	*Protohippus simus* Gidley	Little White River, S. D.	Not figured	Amer. Mus. Nat. Hist.
54	1906	*Neohipparion dolichops* Gidley	Little White River, S. D.	Bull. Amer. Mus. Nat. Hist. Vol. XXII, 1906, p. 149, fig. 14	Amer. Mus. Nat. Hist.
55	1906	*Neohipparion niobrarense* Gidley	Fort Niobrara, Nebraska	Bull. Amer. Mus. Nat. Nist., Vol. XXII, 1906, p. 152, fig. 18	Amer. Mus. Nat. Hist.
56 (31)	1906 (Dec.)	*Archœohippus ultimus* (Cope) Gidley	Cottonwood Creek, Oregon	Bull. Amer. Mus. Nat. Hist., Vol. XXII, 1906, p. 357, figs.	Amer. Mus. Nat. Hist.
57	1907	*Merychippus campestris* sp. nov.	Cottonwood Creek, Oregon		Amer. Mus. Nat. Hist.
58	1907	*Hypohippus osborni* sp. nov.	Pawnee Buttes, N. E. Colorado		Amer. Mus. Nat. Hist.
59	1907	*Parahippus pawniensis* sp. nov.	Pawnee Buttes, N. E. Colorado		Amer. Mus. Nat. Hist.
60	1907	*Parahippus coloradensis* sp. nov.	Pawnee Buttes, N. E. Colorado		Amer. Mus. Nat. Hist.

II. Revision of the Miocene and Pliocene Equidæ.

The types and original descriptions are given in chronological order, and the notation corresponds to that of the chronological table.

1. *Hippodon speciosus* Leidy.

Hippodon speciosus Leidy, Proc. Acad. Nat. Sci. Phila., 1854, p. 90.

Type: a lower molar. (Type specimen not located.)
Type locality, Bijou Hills, South Dakota ("Nebraska Territory").
Horizon: Middle or Upper Miocene.

Author's description (*op. cit.*). "An inferior molar of a solipedal animal, apparently intermediate to *Equus* and *Anchitherium*."

The definition given by Leidy is inadequate. Moreover the type being a lower molar would probably show no distinguishing characters, even if located. The genus and species are therefore indeterminate.

2. **Neohipparion occidentale** (*Leidy*).

Hipparion occidentale Leidy, Proc. Acad. Nat. Sci. Phila., 1856, p. 59.
Hippotherium occidentale Cope, Proc. Amer. Phil. Soc., XXIII, 1886, p. 359.

Type: Four upper teeth, apparently of a single individual (rt. p^2, p^3, and m^2, and 1. p^3 (No. 3, Phila. Acad. Nat.Sci. coll.); No. 10794, cast, Am. Mus. Nat. Hist. coll.).

Type locality: Little White River, So. Dak. ("Nebraska Territory").

Horizon: Upper Miocene, Nebraska.

Author's description (*op. cit.*): "The internal isolated enamel column of the upper molars, on the worn crown, is elliptical and more than twice the length of the breadth. The central column of the same teeth are comparatively moderately folded."

Measurements.[1]

Diameters of p^2:	anteropost.	31.5 mm.,	transv.	23.5 mm.
" " p^3:	"	26.5 "	"	25 "
" " m^2:	"	23 "	"	22 "

Anteroposterior diameter of protocones, p^2 8 mm., p^3 10 mm., m^2 8 mm.

To the description given by Leidy the following characters may be added:

[1] As the measurements given by Leidy, Cope and others were not always taken in a uniform way, some measurements including cement and others not including it, I have remeasured the type specimens where practicable. Transverse diameters are taken across the mesostyle and the posterior half of the protocone, exclusive of cement.

(1) The enamel foldings or plications of the fossette borders in the upper molariform teeth are comparatively complicated but not so elaborate as is usual in the European species of *Hipparion.* (2) The free protocone is relatively large, and flat-elliptical in cross section; (3) hypocone small, about one half the size of the protocone; (4) upper premolars relatively long anteroposteriorly; (5) molars, compared with the premolars, comparatively small; (6) tooth crowns long and but slightly curved.

The skull and foot characters of this species are not known.

3. **Merychippus insignis** *Leidy.*

Merychippus insignis Leidy, Proc. Acad. Nat. Sci. Phila., Dec. 1856, p. 311; ibid., May 1858, p. 27.

Protohippus insignis (Leidy) Cope, Bull. U. S. Geol. & Geog. Surv. Terr., Ser. 1, No. 1, 1884, p. 13.

Type: Two right upper milk molars, dp^2 and dp^3, in a fragment of the maxillary (No.....Phila. Acad. Nat. Sci. coll.; No. 10770 cast, Am. Mus. Nat. Hist. coll.).

Type locality: Bijou Hills, South Dakota.

Horizon: Middle or Upper Miocene.

Author's description (*op. cit.*): "The teeth are inserted by distinct fangs; and the crowns strikingly resemble the true molars of ruminants. There are four demiconoidal lobes holding the relationship with one another as in the latter, especially as in the Deer. The outer lobes have almost the exact form as in the true molars of *Oreodon.* The inner lobes resemble those of ruminants but are complicated with accessory folds as in the horse. No cement fills up the interspaces of the lobes nor does it appear to have existed as a part of the structure of these teeth."

Measurements.

Diameters of dp^2:	anteropost.....	22+	mm	transv.	17.5 mm.
" " dp^3:	"	22	"	"	19 mm.

Although founded on teeth of the deciduous series, this genus is well characterized and the permanent molars are now well known from numerous specimens in the American Museum collections from the Pawnee Buttes, Colorado, locality. These specimens represent several species of horses especially distinguished by their brachyodont milk molars with little or no cement and short but truly hypsodont permanent teeth in which cement is a functional part of the tooth crown. In *Protohippus, Hipparion* and *Neohipparion* the milk molars are hypsodont in form and are heavily invested with cement which is a functional part of the tooth, while the permanent

series are longer crowned and more progressive in general than those of *Merychippus*; thus the genus is clearly distinct and was well founded, and may not be united with *Protohippus* as suggested by Cope.

The characters of the type species are less clearly indicated since it is known only from the type specimen. However it may be distinguished by (1) its moderately large size (see measurements); (2) the conical form of the protocone and hypocone; (3) the comparatively deep enamel foldings of the walls of the metaloph; and (4) the well marked ribs on the external walls of the paracone and metacone. These characters apply only to the milk molars.

4. *Hipparion (Hippodon) speciosum* Leidy.

Hipparion (Hippodon) speciosum Leidy, Proc. Acad. Nat. Sci. Phila., 1856, p. 311.
Hippotherium speciosum Cope, non Leidy, Rept. U. S. Geog. Surv. W. of 100th Merid., 1877, p. 322, pl. lxxv, fig. 3.

Type: Same as *Hippodon speciosum*. *Paratypes*, *a*, an unworn upper molar of *Protohippus* sp.; *b*, an upper molar of *Neohipparion* sp.; *c*, an upper molar of *Neohipparion* sp. 2; *d*, a lower molar of uncertain reference. (These specimens are in the U. S. National Museum collection.)

Type locality: Bijou Hills, So. Dak.

Horizon: Middle or Upper Miocene.

Author's description (*op. cit.*): "Accompanying an inferior molar, there is an unworn upper molar and portions of three other upper molars, worn away in various degrees, which appear to be the teeth of *Hipparion*, and appear to belong to the same animal as the tooth referred to *Hippodon*."

In this description no distinctive characters were given by Leidy, and the specimens themselves only show characters sufficient to establish the fact that there are several species represented in this composite lot referable to two distinct genera. The teeth referred to this species by Cope (*op. cit.*) are smaller than those described by Leidy, and, moreover, are of the shorter crowned type, of the Merychippus group. The species, therefore, as proposed by Leidy remains indeterminable.

5. **Hypohippus affinis** *Leidy*.

Anchitherium (Hypohippus) affinis Leidy, Proc. Acad. Nat. Sci. Phila., Mar. 1858, p. 26.
Hypohippus affinis Leidy, Jour. Acad. Sci. Phila. (2), VII, 1869, p. 311.
Protohippus affinis Cope, Fourth Ann. Report Texas Geol. Surv., 1893, p. 20.

Type: Fourth upper milk molar, dp^4, of left side (No. 573, U. S. National Museum coll., No. 10771, cast, Amer. Mus. Nat. Hist. coll.).

Type locality: Niobrara River near Fort Niobrara, Nebraska.

Horizon: Upper Miocene, Nebraska beds.

Author's description of genus and species (*op. cit.*): "..... the same form [of upper molar] as the corresponding teeth of *Anchitherium*, except that the outer surfaces of its external lobes present no trace of median rising. It indicates an animal larger than *A. aurelianense* and about the size of *Paleotherium crassum*."

Measurements.

Diameters of dp^4: anteroposterior.....27 mm., transverse.....28 mm.

This genus, though based on a single upper milk molar, has, like *Merychippus*, since become well established through later discoveries of more complete material. The characters of the genus are especially well shown in the specimen described by Scott under the name of *Anchitherium equinum*, and several well preserved specimens in the American Museum, including a nearly complete skeleton. The genus may now be more definitely characterized as follows: (1) Both deciduous and permanent molariform teeth brachyodont in form, with little or no cement; (2) external walls of paracone and metacone concave and without external median ribs; (3) protocone and hypocone comparatively large and conical, with the protocone about one fourth larger than the hypocone; (4) protoconule and metaconule much reduced, or undeveloped, being nearly obscured in the continuous transverse lophs (protoloph and metaloph); (5) metaconid and metastylid of lower teeth undivided or but slightly divided by a shallow notch at their summit; (6) p_4 and m_1 are the largest of the lower series and of equal transverse width.

The upper molars of *Hypohippus* are especially distinguished from those of *Anchitherium aurelianense* by (1) the comparatively larger and more rounded protocone; (2) the more complete union of the metaloph with the ectoloph; (3) the more nearly continuous protoloph, with a less distinct protoconule; and (4) by the proportionately larger last upper molar, m^3.

Hypohippus is distinguished from *Mesohippus* by the following important characters: (1) the more progressive development of all the lophs of the upper molars; (2) the completely inclosed posterior fossette; (3) the proportionally larger and more rounded protocone; and (4) the development in the latter of a deep lachrymal pit in the facial region of the skull.

The skeletal characters will be discussed under the description of a new species of this genus.

6. **Parahippus cognatus** *Leidy.*

Anchitherium (*Parahippus*) *cognatus* LEIDY, Proc. Acad. Nat. Sci. Phila., 1858, p. 26.

Parahippus cognatus LEIDY, Jour. Acad. Nat. Sci. Phila. (2), Vol. VII, 1869, p. 314.

Protohippus perditus (Leidy) COPE. Fourth Ann. Rept. Texas Geol. Surv., 1893, p. 20.

Type: Three upper milk molars of the left side (No. 567 U. S. National Museum coll.; No. 10772, cast, Amer. Mus. Nat. Hist. coll.

Type locality: Niobrara River, near Fort Niobrara, Nebraska.

Horizon: Upper Miocene, Nebraska beds.

Author's description (*op. cit.*). "The Niobrara collection contains three isolated unworn crowns of upper molar teeth, which have the same form as the upper deciduous molars of *Anchitherium Bairdi* or *A. aurelianense*, except that the outer extremity of the prolongation of the postero-internal lobe branches into several short folds: these latter have the same arrangement as similar but more numerous folds in the same position in *Merychippus*."

Measurements.

Diameters of dp^2:	anteropost.	.25 mm.,	transv.	.18 mm.
" " dp^3:	"	.19 "	"	.20 "
" " dp^4:	"	.20 "	"	.20 "

Again milk molars were taken to establish the type species of a genus, and like those of *Merychippus* and *Hypohippus*, were later regarded by Cope as representing the milk dentition of some species of *Protohippus*. That Cope was again in error is abundantly proven by a restudy of the types and of additional and better material representing both milk and adult teeth. The genus *Parahippus* as now understood may be more fully defined as follows: (1) Both milk and permanent molars brachyodont; (2) cement thin or wanting, not a functional part of the tooth; (3) inner cones (pr and hy) larger than the median conules (pl and ml) although (4) the protocone occupies less than half the transverse diameter of the crown; (5) protoconule distinct, coneform; (6) pre-fossette partially inclosed by a well defined anterior median fold (crochet) of the metaloph; and (6) p_3 and p_4 largest of the lower series, subequal in transverse width. This definition is capable of including *Anchippus texanus* Leidy, *Anchippus brevidens* Marsh and *Desmatippus crenidens* Scott, all of which I regard as species of *Parahippus*.

The genus *Parahippus* is especially distinguished from *Merychippus insignus* and other species of the genus *Merychippus* by (1) the simple lophoid form and much smaller proportions of the median conules, pl and ml, together with the correspondingly large cone-like inner cusps, pr and hy,

which, though more reduced than in *Hypohippus*, still form a part of the internal boundaries of the pre- and post-fossettes respectively. In the milk as well as the permanent teeth of *Merychippus insignis*, the proportions of the inner cones and median conules are reversed, and the protocone and hypocone are entirely excluded from the fossettes by the large crescentic conules.

7. **Protohippus perditus** *Leidy.*

Equus (*Protohippus*) *perditus* LEIDY, Proc. Acad. Nat. Sci. Phila., 1858, p. 26.
Protohippus perditus LEIDY, Jour. Acad. Nat. Sci. Phila. (2), 1869, p. 275.
Merychippus perditus (Leidy) COPE, Amer. Nat., Vol. XXVI, 1892, p. 943.
Protohippus perditus Leidy, GIDLEY, Bull. Amer. Mus. Nat. Hist., Vol. XXII, 1906, p. 136.

Type: A fragment of upper jaw containing the four posterior cheek teeth, p^4 to m^3 (No. 619, U. S. National Museum coll.; No. 10773, cast, Amer. Museum coll.). *Neotype*: A nearly complete skull (No. 10838, Amer. Museum coll.).

Type locality: Niobrara River near Fort Niobrara, Nebraska. Locality of neotype, Little White River, near Rosebud Indian Agency, So. Dakota.

Horizon: Upper Miocene, Nebraska beds. Same for neotype.

Author's description (*op. cit.*): "The portion of jaw is like the corresponding part in the recent Horse.... The enamel folds on the triturating surfaces are even less complex than in the recent Horse, and the antero-internal fold or column has the same form, direction and mode of construction as the postero-internal one."

Measurements.

Diameters of p^4:	anteropost.	20	mm., transv.	22	mm.
" " m^1:	"	19.5	" "	21.5	"
" " m^2:	"	19.5	" "	21	"
" " m^3:	"	20	" "	17.5	"
Height of crown of p^4		36	"		
Total length of series, p^4 to m^3		78.5	"		

The type of this classical genus was founded on a fairly characteristic specimen of an adult individual, but Leidy's definition is far too general in character to be diagnostic. Cope redefined the genus, but he also made its limits too broad by including in it several species properly belonging to other genera.

The genus is now capable of a more definite and restricted definition as follows: (1) Milk molars as well as those of the permanent series hypsodont, with cement a functional part of the crown; (2) molar crowns of permanent series longer than those of *Merychippus* but not more than twice

the length of their anteroposterior diameters; (3) crowns of upper molars moderately curved; (4) fossettes of uppers molar broad and open transversely with well rounded external loops, (5) and simple enamel walls; (6) lateral toes greatly reduced and probably not functional, a character attained by most of the Miocene genera including some species of the Anchitheriinæ group.

The neotype, described by the writer in a former volume of this Bulletin (*op. cit.*), makes possible a more extended description of *P. perditus*. The palate is only moderately arched, except immediately forward of the premolar series where it is especially high. The maxillaries are deeply constricted in this region, and the anterior palatal foramina are small, oval in outline and situated opposite the canines. The basisphenoid is short and broad, and is overlapped by the vomer.

The characters which especially distinguish the type species of this genus are: (1) Its moderately small size, which is less than that of the modern Donkey; (2) the laterally compressed and backwardly directed protocone and hypocone of the upper molars; (3) the shallow, not sharply defined, lachrymal fossa; and (4) the rudimental condition or entire absence of the malar fossa.

8. **Pliohippus mirabilis** (*Leidy*).

Merychippus mirabilis Leidy, Proc. Acad. Nat. Sci. Phila., 1858, p. 27.
Protohippus mirabilis (Leidy) Cope, Amer. Nat., Vol. XXVI, 1892, p. 943.

Type: A fragment of the right maxillary containing the posterior two milk molars, and the first true molar partially calcified. (No. 569, U. S. National Museum coll.)

Type locality: Niobrara River, near Fort Niobrara, Nebraska.

Horizon: Upper Miocene, Nebraska formation.

Author's description (*op. cit.*): "The temporary molars have the same form as the teeth from which the genus [*Merychippus*] was first characterized would have, in a more worn condition. They are invested with cementum, though in less quantity than is usual in the Horse, and it is more readily detached, which appears to have been the case in the two teeth from Bijou Hill. The crowns of the permanent teeth contained within the fragment of jaw under examination have the same form as the corresponding teeth of the recent Horse, with the modifications above noticed [in describing *Protohippus perditus*] characterizing the subgenus *Protohippus*."

Measurements.

Diameters of $dp\frac{3}{}$:	anteropost.	24	mm.,	transv.	21	mm.
" " $dp\frac{4}{}$:	"	26	"	"	21	"
" " $m\frac{1}{}$:	"	25	"	"	22	"

This species, originally referred to *Merychippus* by Leidy, has more the characters of the *Protohippus* group to which it was later assigned by Cope. The milk molars, though short-crowned, are of the true hypsodont type, and are invested with a considerable deposit of cement which is a functional part of the crown. This sufficiently distinguishes it from the species of *Merychippus*. It differs from the *Protohippus perditus* type in (1) its greater size; (2) the relatively broader transverse diameters of both the milk and permanent molars; (3) the comparatively smaller and more rounded protocone and hypocone; and (4) the presence of a deep malar fossa.

All these characters are common to the species of *Pliohippus* as redefined below. I therefore refer the present species to that genus.

9. *Hipparion venustum* Leidy.

Hipparion venustum Leidy, Proc. Acad. Nat. Sci. Phila., 1853, p. 241 (name only).
Hippotherium venustum Leidy, Post-Pleiocene Fossils of South Carolina, 1860, p. 105 (first description).

Type: A left upper molar lacking the protocone, associated with a broken right upper molar in which the protocone is present.

Type locality: Ashley River, South Carolina.

Horizon: Pliocene.

Author's description (*op. cit.*): "Both specimens are from the upper jaw; and they are well characterized, not only by the isolation of the internal median enamel column, but also by the complex plication of the interior or central enamel columns. .... The larger specimen is firm in texture. .... In its present condition it is two inches in length; and possesses a moderate degree of internal and posterior curvature. . . . .The smaller specimen is firm in texture, and brown in color. It is half worn down; tapers toward the root; and is little less than an inch in length. Its inner median enamel column is antero-posteriorly reniform."

Measurements (from Leidy's figures).

Diameters of No. 1, anteropost.	18 mm.,	transv.	16 mm.
" " No. 2, "	15.5 "	"	13 "

These specimens described by Leidy are very incomplete and unsatisfactory as a type. But they represent one of the smallest though apparently very highly specialized species of the group to which they belong. The particular marks of specialization are the comparatively great height of the tooth crowns and the very complex plications of the enamel walls of the fossettes. In these characters and in the small well rounded protocone

this species differs from those of the typical *Neohipparion* and resembles the true *Hipparion* of the *H. gracilis* type.

10. ? **Parahippus parvulus** (*Marsh*).

Equus parvulus MARSH, Amer. Jour. Sci., 1868, p. 374.
Protohippus parvulus MARSH, Amer. Jour. Sci., 1874, p. 251.

Type: Fragments of skeleton, with an upper and a lower molar associated.
Type locality: Antelope Springs, Nebraska.
Horizon: ? Middle Miocene.

Author's description (*for author's description see op. cit.*, 1874, p. 251): At the time Marsh first described this species, he had not noted any teeth associated with the type, hence his first description refers only to some foot bones which he regarded as belonging to a small species of *Equus*. On the examination of an associated upper molar, which he later discovered and described (*op. cit.*), he referred the species to the genus *Protohippus*, as it was then understood. It is evident, however, from Marsh's description that he had in mind the group of which *Merychippus insignis* is the type and which is now considered distinct from *Protohippus*.

Through Marsh's description, which I have verified by a reëxamination of the type specimen, this species is apparently well established, but there remains some doubt as to its generic reference. As noted by Marsh, the anterior fossette is not closed but is confluent with the inner median valley. This arrangement is unknown in *Protohippus* and the adult teeth of *Merychippus*. Moreover, there is no trace of any anterior fold or projection of the metaconule nor any tendency to a complete inclosing of the anterior fossette such as is observed in the milk teeth of *Merychippus insignis*. This together with the proportionally large protocone which exceeds the protoconule in size, seem to place it with the Anchitherinæ rather than with the Protohippinæ group. The fact that the molar under discussion is of the hypsodont or subhypsodont type and has a considerable investment of cement is contrary to this view. But both these latter characters indicate a stage of progression rather than any especial affinities, hence do not necessarily exclude the species from the former group and the specimen from Antelope Station, Nebraska, apparently represents an advanced type closely related, at least, to *Parahippus*. It may, therefore, provisionally be referred to that genus.

11. **Parahippus texanus** (*Leidy*).

Anchippus texanus LEIDY, Proc. Acad. Nat. Sci. Phila., 1868, p. 231.

Type: A portion of an upper molar, m^1 or m^2, lacking the outer wall of the ectoloph.

Type locality: Washington Co., Texas.

Horizon: ? Upper Miocene. (Obtained from a well.)

Author's description (*op. cit.*): "The size of the tooth, as well as the general form and proportions, have been nearly as in the European *Anchitherium aurelianense*. Six lobes, as in the latter, enter into the constitution of the crown. The external lobes, imperfect, appear to have the same form as in *Anchitherium*. The inner lobes also have the same form but are proportionately less robust, while the median lobes are more so. The postero-median lobe pursues the same course as in *Anchitherium* and likewise, as in this, joins the outer lobes at their junction. From near the middle of its course it gives off a process directed towards the interval of the antero-internal and antero-median lobes and ceasing short of them. This process looks as if disposed to join the contiguous portion of the antero-median lobe, together with it to form a crescentoid lobe, embracing the antero-external one, as in the corresponding columns of equine teeth. No such arrangement exists in *Anchitherium*. A triangular tubercle, as in the latter genus, occupies the space at the back of the crown, and it appears as if its anterior angle had a disposition to join the contiguous portion of the postero-median lobe, to form with it a crescentoid lobe, in like manner as in the former case, to embrace the postero-external lobe."

Measurements.

The measurements of the type tooth are: anteroposterior diameter, 19 mm.; transverse diameter, 20+ mm.

Leidy's description sufficiently distinguishes *Anchippus texanus* from *Anchitherium* and, though not stated by him, the characters given distinguish it from *Mesohippus* and *Hypohippus* as well. Leidy, however, did not compare it with *Parahippus cognatus*, and it is with this species that it seems most closely related. The type specimens agree in the complete union of the metaloph with the ectoloph, the development of a well defined crochet, and in the general form and proportions of the protocone and hypocone, while they differ only in a few points of minor detail of certainly not more than specific importance. The difference in proportion of crown diameters noted in comparing measurements is in this instance due entirely to the fact that one specimen is an adult molar while the other represents the milk dentition.

The additional material examined representing other species of this group does not apparently show any generic distinctions between *Anchippus* and *Parahippus*.

12. **Protohippus placidus** *Leidy.*

Protohippus placidus LEIDY, Jour. Acad. Nat. Sci. Phila., 1869, p. 277.

Type: A left upper premolar, p^2 (No. 621, U. S. National Museum coll.). *Neotypes*: several specimens from Big Spring Cañon, So. Dakota, the type locality (Nos. 10830, 10840, and others. Am. Mus. coll.).

Type locality: Niobrara River near Ft. Niobrara, Nebraska.

Horizon: Upper Miocene, Nebraska beds.

Author's description (*op. cit.*): "A first upper molar tooth [p^2]....presents extreme simplicity in the arrangement of the enamel, compared with its condition generally in equine animals. The central lakes appear wide and gaping, as in the more posterior teeth of *Protohippus perditus*. No trace of a posterior valley or inflection of the crown exists."

Measurements.

Diameters of p^2: anteropost.....18.5 mm., transv.....16 mm.

P. placidus, founded primarily on a single upper premolar, has become better known through material collected by recent American Museum expeditions, and has been redefined by the present writer.[1]

It is apparently an abundant species in the Nebraska beds, and is represented by several well preserved specimens in the collection from Big Spring Cañon and the Little White River. As now understood the species, under the definition, belongs in the genus *Protohippus*, although in some respects its characters are more those of species referable to *Neohipparion*. The comparatively long-crowned teeth and nearly straight upper molars with their less rounded fossettes, resemble more in general the teeth of *Neohipparion gratum* (Leidy) than they do those of *Protohippus perditus*.

13. **Neohipparion affine** (*Leidy*).

Hipparion affine LEIDY, Jour. Acad. Nat. Sci. Phila., 1869, p. 286.

Type: Five upper molars of one individual, — left m^1, m^2, and p^4, and right p^4 and p^3. (No. 584, U. S. National Museum coll.)

Type locality: Niobrara River, near Fort Niobrara, Nebraska.

Horizon: Upper Miocene, Nebraska beds.

Author's description (*op. cit.*): "Among the collection of equine teeth from the Niobrara River, there are a number of specimens larger than those referred to *Hipparion speciosum*, but having about the same size and proportions as those of *H. occidentale*, or of the existing Ass. They however

[1] Bull. Amer. Mus. Nat. Hist., Vol. XXII, 1906, pp. 140 to 142.

differ from those of *H. occidentale* in the simplicity of arrangement of the enamel, which is not more folded than in the Horse. The internal enamel column is also not only proportionately very much wider than in *H. speciosum,* but also absolutely wider than in *H. occidentale.*"

Measurements.

Diameters of p^3:	anteropost.	26	mm.,	transv.	23	mm.
" " p^4:	"	25	"	"	22	"
" " m^1:	"	24	"	"	22	"
" " m^2:	"	23.5	"	"	19	"
" " m^2:	at middle of crown	21.5	"	"	21.5	"
Height of crown of m^2 (outside)		58	"			

This species is known only from the type, but is apparently distinct, as pointed out by Leidy, from *N. occidentale,* the species which it most nearly resembles.

14. **Neohipparion gratum** (*Leidy*).

Hipparion gratum Leidy, Jour. Acad. Nat. Sci. Phila., 1869, p. 288.

Type: Right upper premolar, p^2, associated with two others, ?m^2 and m^3. (No. 587, U. S. National Museum coll.).

Neotype: An anterior portion of a skull, containing the complete dentition of the left side (No. 10863, Amer. Mus. Nat. Hist.).

Horizon: Upper Miocene, Nebraska beds.

Author's description (*op. cit.*): "The first of the series . . . . resembles the corresponding tooth of the first series ascribed to *Protohippus placidus* in size, form and proportions. The internal column appears on the triturating surface isolated, as in *Hipparion,* but it is a question whether at the same stage of attrition it would not have been associated with the antero-median column, as it appears in the tooth of *Protohippus placidus.* The central lakes are observed to be less gaping than the latter, and their surrounding enamel is rather more folded."

Measurements.

Diameters of p^2:	anteropost.	21.5	mm.,	transv.	17.5 mm.
Height of partially worn crown		31	"		

In size and general tooth characters, this species so closely resembles *Protohippus placidus* that Leidy was apparently in some doubt about its validity, while Cope later considered it synonymous with the latter. However, like *P. placidus, N. gratum* is now better known and has been well characterized through more complete material lately obtained by the American Museum field parties from the type locality in South Dakota and Nebraska.[1] From the neotype and other specimens referable to *H. gratum,*

[1] Bull. Amer. Mus. Nat. Hist., Vol. XXII, 1906, pp. 145–147.

the species may now be more clearly defined as follows: (1) Protocone usually small, and elliptical in cross-section; (2) enamel borders of fossettes more deeply folded than in *P. placidus*; (3) anterior border of anterior fossette, at least in the premolars, infolded; (this fold does not appear in any specimen examined of species referable to *Protohippus*, but is apparently characteristic of species referable to *Hipparion* or *Neohipparion*); (4) both lachrymal and malar fossæ moderately deep, but limited in area; (5) anterior palatal foramina opening backward into long, narrow slits, as in the modern horses; (6) palate high arched, especially anteriorly; (7) nasals short-tipped, but very broad where they join the premaxillaries. The lower jaws are short and deep as in *P. placidus*, but with the following differences: (1) The symphysis is longer, while the length of jaw forward of the premolars is comparatively less than in *P. placidus*; (2) the angle of the jaw is proportionally smaller; and (3) the lower border of the ramus is much more curved or bowed.

15. **Pliohippus supremus** (*Leidy*).

Protohippus supremus Leidy, Jour. Acad. Nat. Sci. Phila., 1869, p. 328.
Protohippus mirabilis (Leidy) Cope, Fourth Ann. Rept. Geol. Surv. Texas, 1893, p. 25.
Protohippus supremus (Leidy) Gidley, Bull. Amer. Mus. Nat. Hist., Vol. XXII, 1906, p. 143.

Type: A left upper molar, m^1, or m^2. *Neotype*: A considerable portion of a skull containing milk molars (No. 10844, Amer. Mus. coll.).

Type locality: "South Fork of White River" (Little White River), S. Dakota.

Horizon: Upper Miocene, Nebraska beds.

Author's description (*op. cit.*): "Three isolated upper molars, larger than any of the above from the same locality [Little White River, S. Dakota]. In structure they bear a resemblance to those of *Protohippus perditus* more than to those of any of the other equine species indicated, but they are much larger, and probably belong to another species of the genus."

Measurements.

Diameters of m^1, anteropost.	24 mm., transv. 25 mm.
Height of crown	48 "

This species, founded on three unassociated upper molars, was regarded by Leidy as belonging to the genus *Protohippus*, and as differing from *P. perditus* only in size. However, through a better knowledge of the types and the examination of more complete material the species is now well established.

In the publication above cited, I redescribed this species under its original genus name *Protohippus,* but it apparently belongs more properly to *Pliohippus,* as that group is now distinguished from *Protohippus,* it being closely related apparently to *Merychippus mirabilis* Leidy, I therefore now assign it with that species to the genus *Pliohippus.*

The principal characters, as shown especially in the neotype, distinguishing this species from *P. mirabilis* are: (1) Its size which considerably exceeds that of *P. mirabilis*; (2) the more narrow proportions of the upper milk molars; (3) the greater complexity of the enamel foldings of the upper molars of both the milk and permanent series; and (4) the differences in form of the malar fossa, which has no dividing ridge and is comparatively smaller and shallower than in *P. mirabilis.* The basisphenoid is proportionally longer than in *Protohippus perditus* and is not overlapped by the vomer.

16. *Merychippus paniensis* (Cope).

Hippotherium paniense Cope, Bull. U. S. Geol. Surv. Terr. No. 1, Jan. 1874, p. 12.

Type: Right upper molar, m^1, associated with a left upper m^3. (No. 8260, Amer. Mus. coll.)

Type locality: Pawnee Buttes, N. E. Colorado.

Horizon: Middle Miocene, Pawnee Creek formation.

Author's description (*op. cit.*): "The latter [a right upper molar, m^1 above] is characterized by the generally greater simplicity of the enamel boundaries of the lakes as compared with the same portions of *H. speciosum,* with which it agrees in size. The only plications to be observed are the usual opposite ones entering the lakes from the middle of their adjacent boundaries, and a slight one at the inner angle of the same border of the anterior lake. The inner crescents are united, the posterior retaining its width posteriorly and giving off the posterior inner column from its anterior half. Both the internal columns are longitudinally oval and rather small, the anterior well separated."

Measurements.

Diameters of m^1: anteropost.	18.5 mm.	transv.	20 mm.
" " (associated) m^3: anteropost	20 "	" "	18.5 "
Height of crown, m^1, outside	26 "	inside	11.5 mm.
" " " m^3, "	30 "	" "	16 "

This species is not well characterized, since it is known only from the type specimen and other isolated teeth, yet the short crowns, which when unworn are but little longer than their antero-posterior diameters, together with the more primitive proportions and form of the inner cones, p_2 hy,

than is observed in the Upper Miocene species mark this species as definitely referable to *Merychippus*, as that genus is now understood.

17. *Merychippus labrosus* (Cope).

Protohippus labrosus Cope, Bull. U. S. Geol. and Geog. Surv. Terr., No. 1, Jan. 1874, p. 13.

Type: A mandible and a portion of the right maxillary bone containing five molars.

Type locality: Pawnee Buttes, N. E. Colorado.

Horizon: Middle Miocene, Pawnee Creek beds.

Author's description (*op. cit.*): "Symphysis, flat, shallow; no diastema between their incisor and canine teeth; *P. labrosus*....*Protohippus labrosus* resembles the two species described by Leidy as *Merychippus*, in the short crowns and long roots of the molar teeth, with thickened external ridges separated by thin bands of cementum. It therefore differs from *Protohippus perditus* and *P. placidus*, resembling the first named in size."

Measurements of type[1] (after Cope).

Diameters of p^2:	anteropost.....	22 mm., transv.....	19 mm.
" " m^1:	"	18 " "	22 "
Longitudinal diameter [height] of m^1.....			11 "

Unfortunately the type of this species cannot at present be located and it was apparently not figured by Cope. The disposition of this species must rest therefore on Cope's definition and measurements. These are sufficient to place the species in the genus *Merychippus*, but farther than that it is at present of rather uncertain standing.

18. **Merychippus sejunctus** (*Cope*).

Protohippus sejunctus Cope, Bull. U. S. Geol. Surv. Terr., No. 1, Jan. 1874, p. 15.

Type: Complete skull and lower jaws with entire dentition, and parts of the skeleton associated. (No. 8291, Amer. Mus. coll.)

Type locality: Pawnee Buttes, N. E. Colorado.

Horizontal: Middle Miocene, Pawnee Creek beds.

Author's description (*op. cit.*): "The side of the cranium displays a considerable depression in front of the orbit,....The *P. sejunctus* is identical in measurements with the *P. labrosus*, and agrees with it in the simplicity of the enamel boundaries. It is also short-crowned, but the character is not

[1] For other measurements see Cope, Bull. U. S. Geol. Surv. Terr., No. 1, p. 14.

so marked as in the latter. It differs strikingly in the deep and convex symphysis, and, in the only specimen in which its alveolar border is preserved, in the hiatus separating the inferior canine from the incisors. It exhibits, also, the small and one-rooted first premolar of the *P. perditus.*

"The adjacent horns of the lakes of the molars are more produced outwardly than the remote ones, and the enamel borders have no plications. The sections of the inner columns are oval posteriorly and subround anteriorly. . . . The canines are separated by a considerable interval from the third incisors. The inferior molars are similar, in general, to those of *P. labrosus.*"

Measurements of type (in part).

Diameters of p_2:	anteropost.	24	mm.,	transv.	20	mm.
" " p_3:	"	18	"	"	22	"
" " p_4:	"	19	"	"	22	"
" " m_1:	"	16.5	"	"	21	"
" " m_2:	"	18.5	"	"	22	"
" " m_3:	"	20.5	"	"	18.5	"
Total length of complete series less p_1					175	"
Length of diastema between p_2 and i_3,					54.5	"
Total length of skull taken on basal line,					325	"

This splendid type is a marked exception to those previously described and admits of a far more complete study and better definition of the species than is usual.

While Cope's description adequately separates the species from *Protohippus perditus,* he did not sufficiently distinguish it from *P. labrosus* Cope. According to Cope's statement they are identical in measurements and agree in the general characters of the teeth, but they differ in the form of the lower jaw symphysis and the presence of a hiatus in *P. sejunctus* which does not exist in *P. labrosus* separating the inferior canine from the incisors. These characters are of but little value since they are influenced greatly by age and individual variation. However, since the type of *P. labrosus* cannot now be compared, *P. sejunctus* may be retained as a well established species.

The comparatively short crowns of the molars and the more generalized character of their cusps are features in common with species of *Merychippus,* making the present species more properly referable to that genus.

19. **Pliohippus pernix** *Marsh.*

Pliohippus pernix Marsh, Amer. Jour. Sci., Feb. 1874, p. 252.
Protohippus (*Pliohippus*) *pernix* (Marsh) Gidley, Bull. Amer. Mus. Nat. Hist., Vol. XXII, 1906, p. 144.

[1] For description of skeleton and other measurements see Cope: *op. cit.*

Type: A considerable portion of a skull and lower jaws, including nearly complete dentition, associated with foot bones and other parts of the skeleton.

Type locality: Niobrara River, Nebraska.

Horizon: Upper Miocene, Nebraska beds.

Author's description (*op. cit.*): "This genus closely resembles *Protohippus* Leidy in its dentition, but differs in the absence of lateral digits, which are only represented by slender splint bones. From the true *Equus*, the present genus, may be distinguished by the presence of a large antorbital fossa; by the functional first upper premolar; and by a different composition of the crowns of the upper molars."

Measurements of Type.[1]

Diameters of p^2:	anteropost.	31	mm.,	transv.	22	mm.
" " p^3:	"	22.5	"	"	28.5	"
" " p^4:	"	22.5	"	"	28.5	"
" " m^1:	"	20	"	"	27	"
" " m^2:	"	21	"	"	27	"
" " m^3:	"	25	"	"	27	"

Unfortunately the specimen representing the type species of this genus is that of an old individual with the teeth so much worn as to nearly obliterate their distinctive characters. However, their general features may be inferred with some degree of accuracy.

Marsh founded the genus primarily on the absence of complete lateral digits and the reduction of the metapodials, II and IV, to mere splints as in the genus *Equus*. The evidence for this advanced stage of development is only negative, however, since an examination of the type specimen shows that all the lateral metapodials represented are broken and the distal ends have not been preserved. They are much reduced distally, but not more so than in some specimens in the American Museum collection which still possess small but perfect lateral digits.

Other characters, however, especially those of the skull and teeth, seem to mark as distinct the group of horses of which *Pliohippus pernix* is typical. The type restudied presents the following characters: The skull in general appearance is like that of *Equus*, but is readily distinguished from that genus by (1) the shorter proportions of the muzzle, (2) the greater depth of the angle of the lower jaw (3) the proportionally shorter crowned and more curved molars, and (4) by characteristic facial pits or fossæ.

The group is apparently very nearly allied to *Protohippus* of the *P. perditus* type. But it may be distinguished from the typical *Protohippus* by the following characters: (1) The larger size, so far as known, of the species comprising the group; (2) the proportionally greater transverse diameters

[1] For other measurements see Marsh, *op. cit.*

of the upper molariform teeth; (3) the presence of the deep malar pit which is apparently wanting in *Protohippus*; (4) the less constriction of the muzzle; and (5) the comparatively longer basisphenoid, which is not overlapped by the vomer.

As now understood *Pliohippus* Marsh may retain the rank of a full genus closely allied to *Protohippus*. The distinctions, however, are based on very different characters from those originally employed by Marsh.

20. **Pliohippus robustus** *Marsh.*

Pliohippus robustus Marsh, Amer. Jour. Sci. (3), Vol. VII, 1874, p. 253.

Type: Portions of skull and teeth, associated with foot and limb bones (No. 3008, Yale Museum coll.).

Type locality: Niobrara River, Nebraska.

Horizon: Upper Miocene, Nebraska beds.

Author's description (*op. cit.*): "This species was nearly the same size as that last described [*P. pernix*], but the limbs were shorter and stouter. The first upper premolar is much larger, and the upper molars are longer, and much curved. The crowns of these teeth have a very similar arrangement of the enamel, but the folds are more complex."

Measurements of Type.[1]

Diameters of p^2: anteropost.	29 mm.,	transv.	22.5 mm.
" " p^3: "	26 "	"	24 "
" " m^2: "	25 "	"	22 "
Height of crown, m^2 (outside)	62 "		

Aside from the difference in proportions of the limb bones, the characters given by Marsh to distinguish this species from *P. pernix* are of but little value, since they are in this instance for the most part indicative of age differences only. The type of *P. pernix* is of an old individual while that of *P. robustus* represents a young adult.

The comparative measurements of the limb and foot bones, and the difference in transverse diameters of the upper molars which are but slightly affected by wear, do indicate, however, a somewhat smaller size and more robust proportions for *P. robustus*, as pointed out by Marsh. The species may be further distinguished from *P. pernix* by the difference in form and character of the median terminal phalanges. In *P. robustus* the terminal phalanx is well rounded with the posterior external processes much reduced, as in the modern horse, but the plane of the proximal articular facet is

[1] For other measurements see Marsh, *op. cit.*

directed more backward as in other species of Miocene horses. In *P. pernix* the ungual phalanx is more elongate and the posterior external processes are very prominently developed.

This species is not clearly distinguished from *P. supremus* (Leidy). It agrees with the latter in size and general characters so far as they are known, but there are not enough parts preserved in common to make that point clear.

21. ? *Parahippus avus* (Marsh).

Protohippus avus MARSH, Amer. Jour. Sci., Vol. VII, 1874, p. 253.

Type: Several associated teeth (No. — Yale Museum coll.).

Type locality: Cottonwood Creek, Oregon.

Horizon: Middle Miocene, probably Mascall beds.

Author's description (*op. cit.*): "The molar teeth have very short crowns, and are inserted by distinct fangs. The enamel is covered with a thick coat of cement. The molars are considerably worn, and the pattern of the enamel thus produced nearly resemble that in the corresponding teeth of *Anchitherium*, with which the present teeth agree, also, in form and arrangement. . . . The outer concavities of the external lobes are without any median elevation. The posterior inner cone is larger than the one in front. All the lower molars have an outer basal ridge." etc.

Measurements of type (after Marsh).

Space occupied by six upper molars,	110	mm.
Space occupied by three upper premolars,	57	"
Anteroposterior diameter of second upper premolar,	23	"
Transverse diameter,	22	"
Anteroposterior diameter of last upper molar,	17	"
Transverse diameter,	22	"
Extent of three lower premolars,	57.5	"
Anteroposterior diameter of first lower premolar,	20.5	"
Transverse diameter,	15	"
Anteroposterior diameter of first lower true molar	18	"
Transverse diameter,	16	"

Marsh evidently recognized the Anchitherium-like characters of this species, although he placed it in the genus *Protohippus*. Without question it belongs to the Anchitheriinæ, as especially indicated by the large inner cones and small median conules, but the proper generic reference under this group is at present somewhat uncertain.

22. **Parahippus brevidens** (*Marsh*).

Anchippus brevidens MARSH, Amer. Jour. Sci., Vol. VII, 1874, p. 254.

Type: Three upper true molars of a single individual, m^2 and m^3 of left side, and m^3 of right side (No. . . . . Yale Museum coll.).

Type locality: Oregon, probably Cottonwood Creek.

Horizon: Miocene, ? Mascall beds.

Author's description (*op. cit.*): "These teeth agree in the general structure of their crowns with the type of *Anchippus texanus*, but the antero-median lobe is placed further forward, and hence its worn surface is not in the same line with that of the antero-internal lobe. The posterior crescentoid tubercle, also is isolated, and wears into an ear-shaped lobe, enclosing a pit with cement. The crowns of these molars are unusually short, even when unworn. They all have distinct fangs, and their enamel is covered with cement. The outer lobes have only a faint indication of a median ridge on their concave faces. The buttresses that enclose these faces are prominent."

Measurements (after Marsh).

Anteroposterior diameter of first upper true molar,	17.5 mm.
Transverse diameter,	22 "
Anteroposterior diameter of last upper molar,	17 "
Transverse diameter,	21.5 "
Height of unworn crown of last molar,	15 "

This species was founded on adult molars as stated by Marsh, and not on milk teeth as supposed by Cope.[1] The teeth are of the *Anchippus texanus* type, but differ from that species in (1) the considerable investment of cement; (2) the much greater angulation of the transverse lophs, especially the metaloph which is directed forward from the hypocone and at the crotchet turns at nearly a right angle to join the ectoloph; and (3) in the presence of a slight crenulation of the enamel walls of the metaloph, but this character is less marked than in *Desmatippus crenidens* Scott.

23. **Merychippus calamarius** (*Cope*).

Hippotherium calamarium COPE, Proc. Acad. Nat. Sci. Phila., Vol. XXVI, 1875, 259.

Type: Portion of the palate containing most of the teeth of both sides. (No. 2572, U. S. National Museum coll.)

Type locality: Pojuaque, north of Santa Fé, New Mexico.

Horizon: Middle Miocene; Santa Fé marls.

[1] Fourth Ann. Rept. Texas Geol. Surv., 1893, p. 23.

Author's description (*op. cit.*): "The species is allied to the *H. paniense* Cope, and differs from *H. occidentale*, *H. speciosum* and *H. gratum* of Leidy in the relative form and size of the interior dental column.....In the typical or New Mexican species the column is large, and its centre is anterior to the middle transverse line of the crown. In the present state of attrition,....this column presents an angular projection towards the inner anterior crescent, betraying an approach to the union seen in Protohippus, which is in the fifth molar of the right side of the present horse, actually accomplished through the medium of a narrow isthmus....The borders of the lakes are much plicate, the posterior border of the anterior lake having from four to six inflections....The first premolar is quite small, and is two-rooted....The palate is wide and well arched."

Measurements.

Diameters of p^2:	anteropost.	25	mm.,	transv.	21	mm.
" " p^3:	"	.....21.5	"	"	24	"
" " p^4:	"	21	"	"	23	"
" " m^1:	"	20	"	"	22	"
" " m^2:	"	21	"	"	21	"
" " m^3:	"	20	"	"	.....?17	"

This species was fairly well defined and its affinity to the *H. paniense* type of horse was recognized by Cope. But the characters given, which are in substance the shortness of the tooth crowns, the primitive form of the inner cones (*pr.* and *hy.*) of the upper molars, and the less specialized character of the teeth in general, are distinctive of *Merychippus* as that genus is now understood, hence it is more properly referable to *Merychippus* than to *Hipparion*.

24. *Merychippus seversus* (Cope).

Stylonus seversus Cope, Paleontolog. Bulletin, No. 30, p. 14, Dec. 3, 1878.
Hippotherium seversum (Cope) Wortman, Kansas City Rev. Sci. and Ind., Vol. VI, 1882, p. 73.

Type: A right upper molar tooth, ?m^2 (No. 8180, Amer. Mus. coll.).
Type locality: Cottonwood Creek, Grant Co., Oregon.
Horizon: Miocene, ? Mascal beds.

Author's description (*op. cit.*): "*Stylonus* is allied to *Hippotherium* in details, including the isolation of the anterior internal enamel covered column....It differs from it in the fact that the posterior internal column is isolated in the same manner as the anterior."

In a later publication,[1] under *Hippotherium seversum*, Cope more fully

[1] Proc. Amer. Phil. Soc., Vol. XXVI, 1889, p. 457.

described the type specimen as follows: "Crown of superior molar moderately elongate and curved. Grinding face subquadrate. External ridges prominent. Section of anterior internal column oval, with an apex directed outwards at a short distance anterior to the single internal median loop. Posterior internal column also oval in section, distinct from posterior internal crescent, and without apiculate angle in specimen at present state of wear. Crescents narrow, separated by rather wide lakes entirely filled with cementum. Lake borders simple; anterior with a trace only of an anterior notch; posterior with a strong posterior notch. Opposite adjacent borders with one notch on the posterior and two on the anterior crescents, the latter inclosing a small loop in the usual position. External cement layer thin."

Measurements of type tooth.

Height of crown.....28 mm. outside, 16 mm. inside.
Anteroposterior diameter,.....17.5 "
Transverse diameter,.....16.5 "

The type specimen is a tooth but slightly worn, hence the characters given by Cope indicate a small species of the *Merychippus* group, but with somewhat longer crowned teeth than the typical species of that genus. Since the knowledge of this species is confined to the characters of a single tooth, the type, it is at present of rather indefinite determination

25. **Pliohippus spectans** (*Cope*).

Hippidium spectans Cope, Amer. Nat., Vol. XIV, 1880, p. 223.

Type: A left upper molar m^2 and an associated upper premolar, p^2, (No. 8183, Amer. Mus. Coll.).

Type locality: Cottonwood Creek, Oregon.

Horizon: Upper Miocene, ? Rattlesnake formation.

Author's description (*op. cit.*): "The crowns of these teeth are very long and slightly curved, and the roots are short. The internal columns are relatively small and subequal in size, and are flattened in outline. A peculiarity of the species is seen in the great transverse width of the lakes which, at the middle, is equal to the anteroposterior diameter. The crescents, and especially the inner ones, are correspondingly narrow. The enamel borders are simple, there being only a few notches on the adjacent faces of the lakes. One loop projects from the inner enamel border, almost reaching the anterior inner column. Cement abundant."

Measurements of type teeth.

Diameters of m^2, anteropost.....26.5 mm., transv.....26.5 mm.
" " " " (at base)..24.5 " " .....29.5 "
" " p^2 .....35 " " .....25 "
Height of crown of m^2, outside.....46 "
" " " " " inside.....26 "
" " " " p^2 outside.....26 "
" " " " " inside.....24 "

Compared with the South American genus *Hippidion,* to which Cope referred it, the type of this species shows the following important differences. (1) The crowns of the upper molars are curved but to a less degree; (2) the fossettes are broader transversely; and (3) the enamel walls of the transverse lophs are less plicated and thicker making a heavier line in the cross-section pattern of the tooth crown. (4) The ribs, or styles, of the ectoloph (ps. and ms.) are less prominent.

In all these characters *H. spectans* Cope resembles the known species of *Pliohippus,* as at present defined. I therefore transfer it without question to this genus.

26. **Neohipparion montezumæ** (*Leidy*).

Hippotherium montezumæ Leidy, Proc. Acad. Nat. Sci. Phila., Vol. XXXIV, 1882, p. 291.

Type: An upper premolar, p^3 or p^4, of the right side (No. 3304, U. S. Nat. Mus. coll.).

Type locality: Lacualtipan, Hidalgo, Mexico.

Horizon: ? Upper Miocene.

Author's description (*op. cit.*): "The specimens indicate a species about the size of *Hippotherium venustum* and *H. speciosum,* but the folding of the enamel on the triturating surface of the upper molar.... is sufficiently different from the arrangement in the corresponding teeth of those species, to render it probable that the fossils belong to neither of them.

"In *H. venustum* the inner column of the superior molars, so far as known, is regularly cylindrical. In the tooth under inspection it is much wider than in the latter."

Measurements.

Anteroposterior diameter of type tooth, 19.5 mm.; transverse diameter, 17 mm.; height of crown, outside, 49 mm., inside, 45 mm.

The characters of this species are little known beyond what are shown in the type tooth, but the large, laterally compressed protocone and different character of the enamel plications, as pointed out by Leidy, seem sufficiently to differentiate it from *H. venustum,* while its small size and comparative

great length of crown apparently distinguishes it from any other species previously described. Its general characters are those of the *Neohipparion* species.

27. *Neohipparion sinclairi* (Wortman).

Hippotherium sinclari WORTMAN, Kans. City Rev. Sci. & Ind., Vol. VI, No. 2, 1882, p. 73.

Type: An upper premolar of the left side (No. 8178, Amer. Mus. coll.).
Type locality: Cottonwood Creek, Oregon.
Horizon: Upper Miocene, ? Rattlesnake formation.

Author's description (*op. cit.*): "Some species of *Hippotherium* exhibit an enlargement of the antero-internal lobes of the upper molars almost equal to that of *Equus* with a marked tendency to confluence. A new species from the Loup Fork beds of Oregon which may be called *Hippotherium sinclairi*, exhibits these characters of the superior molars in common with *H. occidentale*. It may be distinguished from the species, however, by its small size and the less marked concavity of the inner contour of the antero-internal lobe."

Measurements.

Diameters of type tooth: anteroposterior.....20 mm., transverse....19.5 mm.
Height of crown,.....42 mm.

This species is known only from the type tooth, a single upper molar, which presents the characteristics of the genus *Neohipparion*. It is somewhat larger than *N. montezumæ*, and differs from that species in the relatively larger and differently formed protocone, and more simple enamel plications. The inner face of the protocone, in *N. sinclairi*, is slightly concave as in *N. affine*.

28. **Neohipparion montezumæ** (*Leidy*).

Hippotherium peninsulatum COPE, Amer. Nat., Vol. XIX, 1885, pl. xxxvi, fig. 5 (name and figure, no description).
Hippotherium peninsulatum COPE, Proc. Amer. Phil. Soc., Vol. XXII, 1885 (1886), p. 150, fig. 1.

Type: A right upper molar, m^2 (No. 8345 Amer. Mus. coll.).
Type locality: Tehuichila, Vera Cruz, Mexico.
Horizon: Miocene.

Author's description (*op. cit.*): "Crown of superior molar long, curved. Grinding face with anteroposterior diameter considerably exceeding the transverse. Internal column large, its section a narrow anteroposterior oval, with both borders convex. Internal enamel borders of internal cres-

cents with a prominent loop at junction,.... Opposite and adjacent enamel borders of the lakes, with several close and deep plications, which nearly cut off the adjacent horns....The median and anterior external ribs of the crown are well developed, and there is but little cement on the grooves."

Measurements.

Diameters of type tooth, anteroposterior, 17.5 mm., transverse 15 mm.
Height of crown, 51.5 mm. outside, 40 mm. inside.

This species also is founded on a single upper tooth. In the characters of the comparatively long tooth crown, the size and form of the protocone, and the plications of the enamel fossette borders, it agrees very closely with *N. montezumæ* (Leidy). The tooth, a true molar, is somewhat smaller than the type of *N. montezumæ* which is a premolar. The difference in size therefore is not more than might exist between the molar and premolar teeth in the same individual. Moreover, the localities from which the specimens were obtained are not widely separated and the horizons are probably equivalent. It is therefore probable that the species are identical.

29. **Protohippus castilli** *Cope.*

Protohippus castilli Cope, Amer. Nat., Vol. XIX, 1885, p. 1208, pl. xxxvi, fig. 6; Proc. Amer. Phil. Soc., Vol. XXIII, 1886, p. 150, fig. 2.

Type: An upper molar of the left side.
Type locality: Tehuichila, Vera Cruz, Mexico.
Horizon: Miocene.
Author's description (*op. cit.*): "This horse is represented by a superior molar tooth of a larger animal than the species last described [*H. peninsulatum*], and one only a little smaller than the zebra..... The crown of the tooth is of medium length and is strongly curved inwards. Its grinding surface is a little wider than long, and is worn into two transverse angles ....The lakes are strongly convex inwards and their horns are wide and obtuse. Their borders are simple, there being no folds on the remote sides, and on the adjacent borders only one on the posterior and two on the anterior, of no great depth. There is no loop at the junction of the inner edges of the internal crescents. External ribs of crown prominent."

Measurements (after Cope).

Length [height] of crown		40 mm.
Diameters of grinding face	anteroposterior	21 "
	transverse	23 "

The type tooth, which again is the sole known representative of the

species, has been temporarily mislaid, hence the validity of the species must, for the present, rest entirely on the description and figure given by Cope.

These indicate a true species of the genus *Protohippus*, very closely related to *P. perditus*.

30. **Hipparion ingenuum** (*Leidy*).

Hippotherium ingenuum Leidy, Proc. Acad. Nat. Sci. Phila., Vol. XXXVII, 1885, p. 33, outline figure.

Type: Two upper molars of left side (No. 3306, U. S. Nat. Mus. coll.).

Type locality: Archer, Florida.

Horizon: ? Pliocene.

Author's description (*op. cit.*): "The tooth now under inspection is an upper molar, perhaps the fourth large one of the series. It indicates a small species, little more than half the size of the domestic horse,. . . .The folding of the contiguous borders of the interior enamel islets of the worn triturating surface is less complex than in *H. venustum*, and the internal islet is elliptical instead of circular."

Measurements.

Diameters of m^2, anteropost.....18.5 mm., transv. .....16.5 mm.
Height of crown .....43 mm. outside,.....34 mm. inside.

But little is known of this species beyond what is shown in the type teeth. These indicate a species but little larger than *H. venustum* Leidy, and differing from it only in the characters pointed out by Leidy which are so slight as to be of but little value in separating them. The great differences in the size and form of the protocone, and the enamel plications separate both species very definitely from *H. montezumæ*.

31. **Archæohippus ultimus** (*Cope*).

Anchitherium ultimum Cope, Proc. Amer. Phil. Soc., Vol. XXIII, 1886, pp. 357, 358.

Archæohippus ultimus (Cope) Gidley, Bull. Amer. Mus. Nat. Hist., Vol. XXII, Dec., 1906, pp. 385–388.

Type: An anterior portion of skull with nearly complete dentition (No. 8174, Am. Mus. coll.).

Type locality: Cottonwood Creek, Oregon.

Horizon: Middle Miocene, Mascal formation.

Author's description (*op. cit.*): "Unusual interest attaches to this horse since it is the latest representative in time of the genus to which it belongs.

It is from a horizon above the John Day Miocene, which contains several Loup Fork genera and species, as Protolabis, Hippotherium and Dicotyles. ....The size is less than that of the *A. præstans* Cope and *A. equiceps* Cope (? *A. anceps* Marsh) of the John Day bed, and the dental series has the same length as that of the *A. longicriste* Cope, also of the John Day....The premolars and molars have a well-marked external cingulum, and there is an internal cingulum round the base of the second premolar. The only other cingula are weak ones round the bases of the anterior lobes of the second and third true molars....The diastema separating the canine from the first premolar is long. The latter has but one root and has a rather small crown.

"It is in the cranial characters that this species displays the greatest differences from the John Day species. In the first place there is a profound and large preorbital fossa, separated from the orbit by a vertical bow. The preorbital fossa in the John Day species is shallow, and not abruptly defined. In the next place the anterior border of the orbit is above the anterior border of the last molar tooth. In this it agrees only with the large *A. præstans*; in the *A. equiceps* and *A. longicriste*, the anterior border of the orbit is above the anterior part of the second superior molar. Thirdly, the infraorbital foramen is above the middle of the fourth premolar; it is over the posterior part of the third in the three John Day species. Finally, the nareal notch marks the anterior two-fifths of the diastema; it extends much further back in the John Day species."

Measurements (after Cope).

Length of diastema from I. 3	.047
" " " " C	.035
" " superior molar series	.079
" " " true molars	.034
" " crown of p. m. 1. (greatest)	.007
Diameters of crown of p. m. ii — anteroposterior	.0145
" " " " " transverse	.0145
" " " " m. i — anteroposterior	.011
" " " " " transverse	.015
" " " " m. iii — anteroposterior	.011
" " " " " transverse	.014

This species was fully described under the name *Anchitherium ultimum*[1] by Cope who recognized and pointed out many characters of advanced development over the Oligocene species. A wider knowledge of both the Oligocene and Miocene forms of horses not only confirms Cope's distinctive

[1] Cope used this genus name not because of any supposed affinities to the European genus *Anchitherium*, but because all American species of the *Mesohippus bardi* type were at that time referred to *Anchitherium*. Later writers placed *A. ultimum* with the others in Marsh's genus. *Mesohippus*.

characters, but emphasizes their importance. A restudy of these characters has resulted in placing the species under a new genus, *Archeohippus*. The principal characters distinguishing this genus as published in a recent paper (*op. cit.*) are as follows: The species is more advanced in general than any of the Oligocene horses and compares in degree of progression with the earlier forms of *Hypohippus* and *Parahippus*. From *Mesohippus* and *Miohippus* the genus is especially distinguished by (1) the complete union of the metaloph with the ectoloph in the upper molariform teeth; (2) the proportionally larger size of the protoconule; (3) the greater lengthening of the anterior portion of the skull, as shown in the comparatively longer muzzle; (4) the more backward position of the orbit; and (5) the great development of the lachrymal and malar fossæ.

It differs from *Parahippus* in (1) the absence or but slight development of a crochet on the metaloph; (2) the deeper notching of the external wall of the protoloph between the protocone and protoconule with a correspondingly less notching of the internal protoloph wall; (3) the comparatively more equal proportions of the molars to the premolars, and (4) the presence of a well developed internal basal cingulum.

Compared with *Hypohippus* (1) the protoconule is much larger than in that genus; (2) the molars in relation to the premolars are comparatively larger; (3) the muzzle is relatively longer; (4) the orbit is placed the width of a molar farther backward, and (5) the malar fossa, which is wanting in *Hypohippus*, is well developed, as is also the lachrymal fossa, with which it is nearly confluent, being separated only by a low rounded transverse ridge.

32. **Neohipparion rectidens** (*Cope*).

Hippotherium rectidens Cope, Proc. Amer. Phil. Soc., Vol. XXIII, 1886, p. 360.

Type: An upper? premolar of the right side.

Type locality: Tehuichila, Vera Cruz, Mexico.

Horizon: Probably upper Miocene.

Author's description (*op. cit.*): "The present animal presents very nearly the same enamel folds as the *H. peninsulatum* Cope, of the same locality, including the subquadrate central loop which is nearly cut off from the anterior lake. But the tooth differs in two essential points, and in some minor ones from that species. It is considerably larger, presenting .6 more area of the grinding surface. The shaft of the tooth, instead of being strongly curved, is straight."

Measurements.

Diameters of crown: anteropost.	2 mm.,	transv.	18.5 mm.
Height of crown	41	"	

This species is known only from a single tooth. The wide and compressed isolated protocone, the deeply plicate enamel borders of the fossettes, and the long crown, seem to place it definitely in the genus *Neohipparion*; but its specific relations are at present somewhat indefinite. The characters pointed out by Cope, however, apparently distinguish it from any other described species.

33. **Hipparion plicatile** *Leidy.*

Hipparion plicatile Leidy, Proc. Acad. Nat. Sci. Phila., 1887, p. 310.

Type: An upper molar of the right side (No. 3292, U. S. Nat. Mus. coll.).

Type locality: Levy Co., Florida. "Mixson's bone bed," 10 miles east of Archer, Florida.

Horizon: ? Pliocene.

Author's description (*op. cit.*). "A tooth from the same locality [Mixson's bone bed], indicates a species of *Hippotherium* different from *H. ingenuum* . . . . It is an upper of an animal approximating the Ass in size, and larger than *H. ingenuum.* The triturating surface . . . . exhibits a complexly folded condition of the enamel, quite different from that of the latter."

Measurements.

Diameters of crown, anteropost. . . . . 20 mm., transv. . . . . 22 mm.
Height of crown (much worn) . . . . . 30 "

The type is apparently a true molar with the crown at least half worn away by use, hence the elaborate plications are a distinctive feature. The protocone is small and well rounded like those of *H. venustum* and *H. ingenuum,* and in other respects the characters presented are similar. But the much greater size and the difference in character of the enamel foldings, distinguish it sufficiently from these species.

H. venustum, H. ingenuum and *H. plicatile,* all from the Atlantic coast and from deposits apparently of Pliocene age, form a group of horses differing in some seemingly important respects from any of the western American species of the Miocene period. They represent in general a slightly later phase of development, especially in the greater length of tooth crowns, the stronger development of the external styles, and the much more elaborate plications of the enamel borders of the fossettes.

In these respects, as well as the retention of a more primitive form of protocone, which is small and nearly circular in cross section as in some species of *Merychippus,* these species resemble closely the European *Hipparion* of the *H. gracilis* type. In foot structure, however, so nearly as can

be determined from the very fragmentary material available, they resemble more nearly the American Miocene forms. It seems not improbable therefore, that these species belong to an American branch of the *Hipparion* group of the Old World, rather than to the *Neohipparion* group more typical of this continent.

34. **Merychippus relictus** (*Cope*).

Hippotherium relictum Cope, Amer. Nat., Vol. XXIII, 1889, p. 254.

Type: An upper molar, ? m^1, of the left side, associated with a second upper molar, m^3, and two lower molars (No. 8673, Amer. Mus. coll.).

Type locality: Oregon Desert.

Horizon: Not known, but probably middle or lower Miocene.

Author's description (*op. cit.*): "Represented by two superior and three inferior teeth. The grinding surface is nearly square, and the crown is short, and moderately curved. The section of the internal style is a wide oval, and it presents no angle or point of approximation to the protoconic crescent, and conversely none to the posterior column. The latter has the usual connection with the hypoconic crescent, but projects as far inwards as the anterior area, and is well defined. The enamel borders are quite simple. The usual loop of the posterior inner border of the anterior is rudimental in an anterior true molar, and in the last molar it is small and subround. No isolated loop. A single short process of the border towards the internal column. Cementum abundant."

Measurements.

Diameters of m^1:	anteropost. ..... 16 mm.,	transv. ..... 18 mm.
" " m^3:	" ..... 16.5 "	" ..... 16.5 "
Height of crown of m_1	outside, ... 20 "	inside, ... 14 "
" " " " m^3,	" ..... 16 "	" ..... 12 "

This species, as indicated by the type, is about the size of *Merychippus severus* (Cope), and seems to differ from it only in minor details. The upper molars are relatively shorter crowned apparently, and have a somewhat greater transverse width, indicating a slightly larger form.

While its generic characters are clearly those of the *Merychippus* group, its specific relations are not well defined.

35. *Hippotherium retrusum* Cope.

Hippotherium retrusum Cope, Proc. Amer. Phil. Soc., Vol. XXVI, 1889, p. 446.

Type: Two upper molars (No. 8350, Amer. Mus. coll.).

Type locality: Phillips Co., Kansas.

Horizon: Upper Miocene.

Author's description (*op. cit.*): "The character by which the superior molars of the *Hippotherium retrusum* may be readily distinguished from those of all other species of the genus, is the extraordinary posterior extension of the anterior internal column, which brings it first into contact with the posterior internal column, and then on greater wear unites the two by an isthmus. In the first true molar the area of the column is in contact at its extremities with both the posterior column and the anterior inner crescent....The complexity of the enamel border of the lake is of medium degree....The crowns are robust, of medium length, and curved. That of the second true molar is rather longer than wide; the first true molar is about as wide as long."

Measurements.

Diameters of m^1	anteropost.....	18 mm., transv.....	18.5 mm.
" " m^2:	"	21 " "	17 "
Height of crown, m^1.....			29 "
" " " m^2.....			35 "

This species, known only from the two teeth of the type, is at present of rather uncertain reference. Cope placed it in the *Hipparion* group, but apparently on insufficient grounds. The union of the protocone with the hypocone as well as with the protoconule is frequently observed in species of *Protohippus* and *Pliohippus* where the tooth crown is worn to near its base, hence *H. retrusum* may represent a species of one of these genera which is highly specialized in this respect, the union occurring much nearer the summit of the unworn crown. Or the teeth described by Cope may be abnormal.

36. *Protohippus profectus* Cope.

Protohippus or *Hippidium profectus* Cope, Proc. Amer. Phil. Soc., Vol. XXVI, 1889, p. 447.

Type: Four fragmentary upper cheek teeth (Amer. Mus. coll.).

Type locality: Phillips Co., Kansas.

Horizon: Upper Miocene.

Author's description (*op. cit.*): "The anterior inner column presents in the second individual [the type of *P. profectus*] the same flattened form as in the first above described [*H. retrusum*], but is connected with the anterior crescent by a narrow isthmus, and not in two of the three teeth at least, where the part is preserved, with the posterior crescent. The animal may possibly belong to a species distinct from the *H. retrusum*, and perhaps to

a species of Protohippus or Hippidium. If so, it differs from the known species of those genera in the posterior position and flatness of the anterior column . . . .It approaches nearer to Equus than any known species of those genera."

Measurements.

Diameters of p^2: anteropost. . . . . 45 mm., transv. . . . . 23 mm.
" " $m^?$: " . . . . . 24 " " . . . . . 20 "
Height of crown p^2 . . . . . 19 "
" " " $m^?$ . . . . . 36 "

This species, like *H. retrusum*, is of doubtful reference, and was not well characterized by Cope. Its greater size separates it sufficiently from *H. retrusum*, although its characters so far as they can be made out seem to class it in the same group.

37. *Merychippus sphenodus* (Cope).

Hippotherium speciosum (Leidy) Cope, Ann. Rep. U. S. G. G. S. Terr., 1873 (1874), p. 522; not of Leidy.
Hippotherium sphenodus Cope, Proc. Am. Phil. Soc., Vol. XXVI, 1889, pp. 449, 450.

Cotypes: Two upper premolars (No. 8281, Amer. Mus. coll.).
Type locality: Pawnee Buttes, Colorado.
Horizon: Middle Miocene, Pawnee Creek beds.
Author's description (*op. cit.*): "Their characters are somewhat similar to those of *H. speciosum* in the plications of the enamel, but the form of the internal columns is entirely distinct, referring the species to the group of the *H. calamarium*. The latter species is, however, distinguished by the very short wide form of the anterior teeth, especially of the second premolar."

Measurements.

Diameters of p^2: anteropost. . . . . 25 mm. transv. . . . . 19.5 mm.
" " p^3: " . . . . . 21 " " . . . . . 18 "

This species was founded on single premolars of two individuals. They differ as much, in minor details, between themselves as from *M. calamarium* (Cope), the species with which Cope grouped them. The general characters of the teeth, including the short hypsodont crowns place them in the *Merychippus* group. They apparently agree more nearly with *M. calamarium* than any of the other species described, but with the material at hand their exact distinction or relationship cannot be certainly determined.

38. **Merychippus isonesus** (*Cope*).

Hippotherium seversum Cope, Proc. Amer. Phil. Soc., 1886, p. 359.
Hippotherium isonesum Cope, Proc. Amer. Phil. Soc. Vol. XXVI, 1889, p. 451.

Type: A nearly complete skull and lower jaws associated with a large part of skeleton (No. 8175, Amer. Mus. coll.).

Type locality: Cottonwood Creek, Oregon.

Horizon: Middle Miocene, Mascall beds.

Author's description: (For Author's description of species, which is long and detailed, see Cope, *op. cit.*)

Measurements of type.

Diameters of p^2:	anteropost.	22	mm.,	transv.	16	mm.
" " p^3:	"	19	"	"	18	"
" " p^4:	"	18.5	"	"	18	"
" " m^1:	"	19	"	"	19	"
" " m^2:	"	19	"	"	17	"
Height of crown of p^2		23	"			

(For other measurements see Cope's description, *op. cit.*)

This type has been fully described by Cope, but its distinctions have not been clearly brought out. The short molar crowns with their less specialized characters place the species in the genus *Merychippus*. As at present understood, therefore, *M. isonesus* (Cope) may be briefly redefined as follows: The upper molars are comparatively short crowned and of the true *Merychippus* type. The inner cones, pr and hy, are subequal in size, small and well rounded in outline, and free at their summits in an unworn tooth. The hypocone soon joins the metaconule, or posterior crescent, but the protocone remains distinct as in *Hipparion* and *Neohipparion*. The protocone has a rib, or projection, extending towards the protoconule, or anterior crescent.

In all of these characters and in the general appearance of the comparatively simple enamel foldings or plications of the enamel walls of the fossettes, these teeth very much resemble the type of *M. seversus* (Cope), but their larger size and comparatively shorter crowns sufficiently distinguish them from that species.

Other characters of importance are the comparatively short muzzle, and the large size and form of the facial pit which is single but occupies the position of both the lachrymal and malar fossæ in *Pliohippus* and some species of *Neohipparion*.

This fossa is larger and deeper than in *Protohippus perditus* or any other species of *Merychippus* in which this character is known. It differs

especially from *Phiohippus* in the absence of any dividing ridge between the lachrymal and malar fossæ.

39. **Neohipparion princeps** (*Leidy*).

Hippotherium princeps Leidy, Proc. Acad. Nat. Sci. Phila., 1890, p. 182.
Equus major Lucas, Trans. Wagner Free Inst. Sci., Vol. IV, 1896, p. 49.

Type: An upper premolar, p^3 or p^4, of the right side. (No. 3299, U. S. National Museum coll.)

Type locality: Peace Creek, Florida.

Horizon: Probably Pleiocene or early Pleistocene.

Author's description (*op. cit.*): "The size of the tooth indicates the species to have been as large as the ordinary domestic Horse and therefore the largest species of the genus yet discovered....The tooth, a second or third upper molar, is three inches long in its outer curvature and the worn triturating surface, represented in the accompanying woodcut, measures 15 lines fore and aft and 14 lines transversely. The arrangement of the enamel most nearly approximates the condition observed in *H. occidentale* from our western tertiary formation. The inner column, of uniform breadth the entire length of the crown, measures half an inch fore and aft, and in section is horizontally reniform. The species was a third larger than the *H. gracile*, the largest European form."

Measurements.

Diameter of tooth crown, anteropost.....31 mm., transv.....27 mm.
Height of crown.....75 "

The insufficient material renders it impossible at present to make an entirely satisfactory disposition of the species, but the evidence at hand inclines me to regard it as belonging to the *Neohipparion* group.

Mr. F. A. Lucas (*op. cit.*) has regarded the type specimen as an abnormal or reverted tooth of *Equus major* (*complicatus*), but this supposition seems scarcely warranted in view of the fact that, except for size, the general characters presented are those of *Neohipparion* rather than *Equus*. The protocone is broad anteroposteriorly, compressed transversely, presenting a concave inner face, while it is completely isolated. The hypostyle groove is deep and extends nearly to the base of the crown. The enamel borders of the fossettes are very plicate and deeply folded, and the external ribs, or styles, are more strongly developed than is usual in species of *Equus*. All these characters are *Neohipparion* or *Hipparion* like, but the large size and form of the protocone suggests *Neohipparion* rather than the latter genus.

It seems more probable, therefore, that *H. princeps* represents a very

large and highly specialized species, and perhaps one of the last of the *Neohipparion* group which may have survived almost or quite to the Pleistocene age, being a contemporary of some of the earlier species of *Equus* with whose remains the type tooth was found associated.

40. *Pliohippus gracilis* Marsh.

Pliohippus gracilis Marsh, Amer. Journ. Sci., Vol. XLIII, 1892, p. 347.

Type: An incomplete hind foot.
Type locality: Oregon Desert.
Horizon: Probably Middle Miocene.

Author's description (*op. cit.*): "The frequent reappearance of the second digit as an extra toe in the modern horse would seem to indicate that this feature was functional in a late ancestor, but no fossil equine with two toes has yet been found." [Foot note.] "A small species of *Pliohippus* from the Pliocene of Oregon may be an exception. An incomplete hind foot in the Yale Museum shows the second metatarsal as a splint bone, the third very long and slender, and the fourth so well developed that it probably supported phalanges. This may be also a case of reversion. The species is new, and may be called *Pliohippus gracilis*."

This species was not well defined by Marsh, nor does the type show any especially distinctive features. The character given, that of the great inequality of the lateral metatarsals, is frequently observed in species of widely different genera of Miocene horses — hence it is not determinative. The species is therefore indefinitely known at present.

44. *Pliohippus simplicidens* (Cope).

Equus simplicidens Cope, Proc. Am. Phil. Soc., Vol. XXX, 1892, p. 124.
Pliohippus simplicidens (Cope) Gidley, Bull. Amer. Mus. Nat. Hist., Vol. XIV, 1901, p. 124.

Type: An upper molar or premolar of the left side, associated with three other upper molars of different individuals.
Type locality: Mount Blanco, Crosby Co., Texas.
Horizon: Pliocene, Blanco formation.
Author's description (*op. cit.*): "The size of the teeth is about that of the *E. occidentalis* and *E. caballus*. The internal column is of moderate antero-posterior extent, its posterior border marking the anterior third of the posterior lake. Its long diameter is considerably less than half that of the crown. A peculiarity found in two of the superior molars, but not in

two others, is that the median dentinal connection between the external and median crescents is interrupted by the continuity of the enamel plates bordering the lakes from the one to the other. This arrangement is frequently seen in the large pm. 3, in the species of *Equus*, but does not occur in the other premolars and molars. It is a reversion to the condition seen in Anchitherium. A principal character of the species is seen in the extreme simplicity of the enamel borders of the lakes. They are without inflection, except the usual loop on the posterior inner border of the anterior lake, and this is simple and widely open at the base. At the point of junction of the median crescents (meta- and paraconules), the usual loop of the internal enamel border is seen. The external median rib is narrowed and not flattened; the anterior rib is more flattened, especially at the present grinding face."

Measurements (from Cope's figure).

Diameters of crown, anteropost.....32 mm., transv.....26 mm.
Height of crown.....60 "

While the type tooth is not available for examination, Cope's published figures indicate that it is a true molar of a young adult individual, hence but slightly worn by use. If true, the character of the interrupted metaloph, mentioned by Cope, has no particular significance.

The principal characters shown in the type as well as the other teeth from the same locality, referable to this species, point to a more primitive phase than any true species of *Equus*. In the simplicity of the enamel foldings, the small size and form of the protocone, and the less reduced proportions of the hypocone, as well as the tendency to a sharp entrant-angular groove between the metaconid and metastylid columns in the lower teeth, the Blanco species resembles more the known species of *Pliohippus*, from the upper Miocene beds, than those of the true *Equus*.

For these reasons I have, in a former publication (*op. cit.*) transferred the species to the genus *Pliohippus*. However, the lack of sufficient material leaves the species of somewhat uncertain reference.

42. **Protohippus pachyops** *Cope.*

Protohippus pachyops Cope, Fourth Ann. Rept. Geol. Surv. of Texas, May, 1893, p. 26.

Type: Skull and lower jaws lacking muzzle and posterior portion of cranium.

Type locality: Donley Co., Texas.

Horizon: Upper Miocene, Clarendon formation.

Author's description (*op. cit.*): "The malar-maxillary ridge is obtusely rounded, and there is no preorbital fossa. There is an oval maxillo-nasal fossa, which is strongly pronounced. The infraorbital foramen issues above the middle of the first true molar. The maxillary bone projects about half the diameter of the last molar tooth posteriorly to it, but this dimension may increase a little, as the animal is not fully grown. The anterior orbital border marks a point above the middle of the last superior molar. The last superior molar is just protruding from the alveolus. The first and second molars are worn. Their crowns have a greater anteroposterior than transverse diameter, and the section of the protocone is greater longitudinally than transversely, although its junction with the paraconule is complete. The enamel of the lake borders is simple, except that that of the posterior wall of the anterior lake presents the usual loops well defined. The superior molars have the crowns long and well curved transversely. In the inferior molars the anterior and posterior lobes of the metaconid have but little anteroposterior extent, and the paraconid and hypostylid are well developed. The column of the last inferior molar, which forms the heel, is quite small."

Measurements (after Cope).

Length of maxillary bone to anterior border of P. m. i		127 mm.
Length of ditto from orbit to preorbital foramen		64 "
Anteroposterior diameter of true molars		84 "
Diameter of crown of M. i	anteroposterior	28 "
	transverse	25 "
Length of crown of inferior true molars		88 "
Length of crown of last inferior molar		30 "
Diameters of M. i	anteroposterior	31 "
	transverse	13 "
Depth of ramus at front of M. i		46 "
Depth of ramus at posterior end of M. iii		67 "

Cope's description of the type is sufficiently accurate and detailed, but his conclusions were based on a misconception of the age of the specimen. The portion of skull was regarded by Cope as representing a young adult animal with the last true molar just protruding from the alveolus. But a more careful examination of the type shows it to be that of a colt still retaining the milk molars, with the first true molar just coming into use and the second just protruding from the alveolus, the third not yet having made its appearance.

This is of especial interest and importance since Cope described and figured a skull, with teeth of a wholly different character, as representing the milk dentition of this species. But the type specimen shows them to be very similar, except for proportions and relative length of crown, to those

of the permanent series. As restudied, the characters of this species are observed to be in general those of the genus *Protohippus*, but differing in several important details, as pointed out by Cope, from any of the foregoing species.

The affinities of the young skull, wrongly referred to this species by Cope, are unmistakable. The brachyodont form of the crowns, which are without functional cement; the large subequal and well rounded protocones and hypocones; and the simple, almost uninterrupted, transverse lophs in which the median conules are so small as to be scarcely observable are characters which make its reference to the genus *Hypohippus* unquestionable. Cope remarked its close resemblance to the type of *Hypohippus affinis* Leidy, with which it also agrees very nearly in size.

The proportions of the teeth and height of their crown are almost exactly those of the tooth representing *H. affinis*, and the specimen may with little doubt be referred to that species.

43. **Protohippus fossulatus** *Cope.*

Protohippus fossulatus Cope, Fourth Ann. Rept. Geol. Surv. of Texas, 1883, p. 30.

Type: Portion of cranium.

Type locality: Donley Co., Texas.

Horizon: Upper Miocene, Clarendon formation.

Author's description (*op. cit.*): "The dimensions of this species are superior to those of any other members of the genus excepting the *P. pachyops* and *P. mirabilis*. It equals the former and is a little exceeded by the latter. The characters of the lateral facial fossæ are peculiar, and as they are exactly alike on both sides of the skull, I believe them to be normal. There is no fossa immediately in front of the orbit, but there is a narrow and deep maxillonasal fossa, whose posterior extremity approaches nearer to the superior part of the orbit than any other. Beneath it, and immediately above the penultimate molar tooth, is a small but well pronounced fossa, which is about as large as would be produced by an oblique impression of the end of the thumb in putty. Immediately anterior to the infraorbital foramen is a wider and shallower fossa. Anterior to this is a fossa directed obliquely downward and forward, as a continuation of the nasomaxillary; and below and in front of this one is a deep concavity of the alveolar border." (For further description see Cope, *op. cit.*)

Measurements (after Cope, in part).

Diameters of m^1:	anteropost.	20 mm.,	transv. 25 mm.
" " m^3:	"	27 "	" 24 "
Total length of molar-premolar series			145 "
" " " molar series			69 "

This species was fully described and fairly well characterized by Cope.

Although comparing in size with the northern Miocene species, which I have regarded as belonging to *Pliohippus, P. pernix, P. robustus, P. mirabilis,* and *P. supremus,* the general skull characters presented are more nearly those of *Prohippus perditus* as that species is now understood. The maxillonasal, or lachrymal, fossa described by Cope is in form and position strikingly similar to that shown in a young skull of *P. perditus* from the upper Miocene beds of South Dakota (No. 10838, Am. Mus. coll.) but it is somewhat deeper and more sharply defined than in the latter. The Texas specimen also shows a deep depression of the skull, not mentioned by Cope, in the median line directly between the orbits, as in the *P. perditus* skull, but it is not divided as in the latter specimen.

Other characters common to both species are, the unusual broadening of the nasals anteriorly, the comparative shortness of the muzzle, and its deep constriction immediately in front of the premolars.

The larger size, the presence of an insipient maxillary fossa, and the greater depth of the lachrymal fossa, sufficiently distinguish the Texas species from *P. perditus,* while suggesting a somewhat more advanced form.

44. ? **Hipparion lenticularis** (*Cope*).

Protohippus lenticularis Cope, Fourth Ann. Rept. Geol. Surv. of Texas, 1893, p. 41.

Type: Two superior molars.

Type locality: Mulberry Canyon, near Goodnight, Texas.

Horizon: Upper Miocene, ("Goodnight beds.") = Clarendon formation.

Author's description (*op. cit.*): "Two superior molar teeth represent this horse in the collection from Goodnight's. They indicate a species of the size of the *Hippotherium speciosum,* and present several peculiarities. The most conspicuous is seen in the form of the protocone, which is long separate from the paraconule. It has an absolutely lenticular section, presenting acute angles anteriorly and posteriorly, and convex surface internally and externally. In this respect it differs from all the species of Hippotherium and Protohippus known to me. The column is fused towards the base with the paraconule, so that an old animal belongs to the genus Protohippus, as in the case with the *Protohippus placidus,* described on a preceding page. As both the teeth of *P. lenticularis* are only partially worn, the pattern of their grinding faces is that of the genus Hippotherium.

"The enamel borders of the lakes are moderately complex, the anterior having the posterior loop nearly isolated, and a trace only of other irregularities, while there are two deep notches of adjacent borders of the

posterior lake. The remote borders of the lakes have each a mere trace of a notch. There is one deep loop of the internal border, which extends to the protocone in one tooth and nearly to it in the other. It is rarely so pronounced in the three-toed horses, and when large is frequently double.

"The crown is curved transversely but not anteroposteriorly."

Measurements (after Cope).

Diameters of No. 1, anteropost....21 mm., transv....19 mm.,..height, 48 mm.
" " " 2, " ...— " " ...18 " .. " 44 "

This species, founded on two isolated upper molars, was described and named under *Protohippus* by Cope. But his reasons for placing it in this genus are insufficient. According to Cope's statement the protocone does not join the protoconule ("paraconule") except near its base, a condition which may frequently be observed in old individuals of the true *Hipparion* or *Neohipparion*. In other respects the characters presented are those of the latter genera rather than of *Protohippus*.

The protocone is small and well rounded, and in this respect is more like the European *Hipparion* than any species described from this country, except Leidy's three species from Florida and South Carolina as mentioned above (page 914). The character of the lenticulate form of the protocone, pointed out by Cope as distinctive of the species, is apparently due entirely to the little worn condition of the tooth crown. Unlike the Atlantic coast species the enamel foldings are comparatively simple and the fossettes are in character more like species of *Neohipparion*. It is therefore with some doubt that I place this species in the genus *Hipparion*.

In 1899 I obtained a second specimen, apparently of this species, from the Clarendon beds of Donley Co., Texas. This very much more complete specimen, consisting of the anterior portion of a skull with full dentition (No. 10584, Am. Mus. coll.) makes possible a better comparison and characterization of the species. The corresponding teeth are nearly identical in size and characters with those on which the species was founded, hence they need no further description except that the protocones of the less worn teeth are lenticulate in form while the others have the usual rounded outline. The special features of importance are seen in the skull characters. The palate is high-arched, the muzzle is comparatively long and slender, and the cranium, as compared with *Protohippus perditus*, has a considerable vertical depth.

The species is especially Hipparion-like in the characters of the facial region. The malar ridge is high and angular, and there is no malar fossa or depression but the lachrymal fossa is especially well developed. Though smaller in area than in the typical *Hipparion gracilis*, it is sharply defined,

and deeply pocketed posteriorly. In its facial characters *H. lenticularis* differs from all other American Miocene horses, so far as known.

45. *Pliohippus interpolatus* (Cope).

Hippidium interpolatum Cope, Fourth Ann. Rept. Geol. Surv. Texas, 1893, p. 42.

Type: Two upper molars.

Type locality: Mulberry Cañon, near Goodnight, Texas.

Horizon: Upper Miocene, ("Goodnight beds.") = Clarendon formation.

Author's description (*op. cit.*): "The form and area of the grinding surfaces are similar to those of the corresponding molars of the domesticated horse (*Equus caballus*). They may be distinguished from the corresponding teeth of the species of Protohippus by the small size of the protocone and hypocone. The former reached posteriorly to the line of the anterior border of the posterior lake, but does not overlap it, as is the case with the species of three-toed horses generally. Its junction with the paraconule is strongly constricted. The internal enamel border between the protocone and hypocone is inflected to a point beyond the line of the internal border of the anterior lake, and in front of its apex it sends inward a deep narrow loop. The lakes are relatively large, and the borders are quite simple. The anterior border of the anterior lake is simple; the posterior border has an inflection but no loop. The exterior border of the posterior lake has one inflection, and its posterior border a slight emargination. Owing to the transverse width of the lakes, their horns are little produced. The crowns are curved transversely, but scarcely anteroposteriorly. Cementum abundant."

Measurements (after Cope).

Diameters of m^1:	anteropost.	28 mm.,	transv.	27	mm.
" " m^2:	"	29 "	"	29.5	"
Height of crown of m^2:		65	"		

This species is somewhat poorly characterized since it is known only from two molars, the type teeth. They are of a young adult individual, hence the fossettes are not so wide transversely as they undoubtedly would be with a greater degree of wear. In other respects, especially in the simplicity of the enamel walls, the small rounded protocone, and the degree of curvature of the tooth crown, they are like the northern species of *Pliohippus* more than those of the South American *Hippidion*. They agree in size with *P. spectans* Cope.

46. ? **Hipparion eurystylus** (*Cope*).

Equus eurystylus Cope, Fourth Ann. Rept. Geol. Surv. Texas, 1893, p. 43.
Hipparion eurystylus (Cope) Gidley, Bull. Amer. Mus. Nat. Hist., Vol. XIV, 1901, p. 125.

Type: A broken lower molar. *Paratypes*: Several lower molars and premolars.

Type locality: Paloduro Cañon, Crosby Co., Texas. *Locality of Paratypes*: Mulberry Cañon, near Goodnight, Texas.

Horizon: Upper Miocene, ("Goodnight beds.") = Clarendon formation.

Author's description (*op. cit.*): "This small but remarkable true horse was first brought to my notice by a broken inferior molar from the Palodura Cañon, where it was found by Mr. Cummins. The horizon of this locality was unknown to me, but the discovery of four additional lower molars at Goodnight's by Mr. Cummins fixes it. It is the most characteristic species of the epoch which intervened between the Loup Fork and Blanco.

"The species belongs with the *E. minutus*, Cope, to a section of the genus characterized by the relatively great width of the metaconid-metastylid column of the inferior molars, and its close appression to the protoconid and hypoconid, and hence by the relatively narrow molar crown; and also by the small size....

"Other specimens examined since the above description was written throw much additional light on its characters. These are four inferior molars, all from Goodnight's, and all apparently from as many individuals. From these it seems that the external faces of the protoconid and hypoconid are flat and not convex as is usual in this genus. Also that the hypoconid throws outwards an acuminate or acute loop just before joining the protoconid, which loop is the summit of an acute ridge of the middle of the external face of the crown." (For further description see Cope, *op. cit.*)

Measurements (after Cope).

Diameters No. 2	longitudinal	55
	anteroposterior	24
	transverse	10
Diameters No. 5	longitudinal	40
	anteroposterior	22
	transverse	12

The type tooth is so fragmentary as to show no particularly distinctive features, therefore, following Cope, the principal characters of the species may be taken from the paratypes. A restudy of these teeth makes it very clear that Cope was not warranted in referring them to the genus *Equus*

The characters throughout are especially those of the *Hipparion* or *Neohipparion* group. The little fold of enamel observed at the antero-external angle of the protoconid, and the appression of the metaconid metastylid column to the protoconid and hypoconid, are characteristic features of the Miocene genera of the *Protohippinæ*. The little anterior fold of the enamel wall is commonly observed in species of this group while it is never present in species of true *Equus*.

The tendency toward flat external faces of the protoconid and hypoconid, and the external median keel, mentioned by Cope, as well as the great height of crown, are characters which suggest *Hipparion* or *Neohipparion* rather than *Protohippus* or *Pliohippus*.

The teeth representing this species are from the same horizon and from practically the same locality as those of *H. lenticularis*. Moreover they agree in size, that is, in anteroposterior diameter, with the corresponding upper teeth of this species, hence it seems quite possible that the two species are identical. But since the lower dentition of *H. lenticularis* and the upper dentition of *H. eurystylus* are not certainly known, this point may not be determined at present.

47. **Protohippus cumminsii** (*Cope*).

Equus cumminsii Cope, Fourth Ann. Rept. Geol. Surv. Texas, 1893, p. 67.
Protohippus cumminsii (Cope) Gidley, Bull. Amer. Mus. Nat. Hist., Vol. XIV, 1901, p. 126.

Type: An upper molar of the left side associated with two other upper molars.

Type locality: Mount Blanco, Crosby County, Texas.

Horizon: Pliocene, Blanco formation.

Author's description (*op. cit.*): "They represent an animal of considerably smaller size than the latter, measuring with the *E. tau* and *E. semiplicatus*. Their enamel borders are entirely simple, as in *E. simplicidens* and are hence different from those of the *E. semiplicatus*. It differs from both the *E. simplicidens* and the *E. tau* in the prominent convexity of the internal wall of the paracone and metacone, from which it results that the external border of each lake is deeply concave, and the horns appear to be strongly produced. The protocone has a very short anteroposterior diameter, in which it resembles the *E. simplicidens*, *E. crenidens* and *E. stenonis*, and differs radically from the *E. tau* and the other species of the Equus beds. It is not bilobate or grooved on the internal face....

"The subcyclindric character of the paracone and metacone approach what exists in Hippidium and some species of the three-toed horses."

Measurements (after Cope).

Diameters of crown, anteropost.....24 mm., transv.....24 mm.
Height of crown.....33 "

This species is represented by only three upper molars from Mount Blanco, Texas.

Although compared principally with species of *Equus*, both the description and figures given by Cope apparently show a much closer relationship with the three-toed horses of the Miocene. The small size and form of the protocone seems to identify this species with the Upper Miocene genera, and the simple, widely open fossettes and concave form of the external walls of the protocone and metacone appear to mark its especial affinities to *Protohippus* or *Pliohippus*. The greater depth of the notch anterior to the protocone, suggests a somewhat more advanced form than any species of *Protohippus* from the Miocene horizon.

48. *Protohippus phlegon* (Hay).

Equus minutus Cope, Fourth Ann. Rept. Geol. Surv. Texas, 1893, p. 67.
Equus phlegon Hay (to replace *E. minutus* Cope, preoccupied), Bull. 159, U. S. Geol. Surv., 1901, p.
Protohippus phlegon (Hay) Gidley, Bull. Amer. Mus. Nat. Hist., Vol. XIV, 1901, p.

Type: A lower molar, ? m_2, of the right side.

Type locality: Mount Blanco, Crosby Co., Texas.

Horizon: Pliocene, Blanco formation.

Author's description (*op. cit.*): "The inferior molar is narrowly hypsodont, and has apparently had but a thin cementum investment. This appears probable, from the fact that it is as thin where protected from weathering as where exposed to it, *i. e.*, in the groove between the external columns. The inner side of the crown shows marked peculiarities. The metaconid and metastylid are appressed to the hypoconid and protoconid, and are spread widely apart so as to be connected by a narrow anteroposterior isthmus, and separated on the internal face of the crown by a wide channel which has a greater anteroposterior diameter than the metaconid and metastylid respectively near the apex of the crown, and an equal width at the base of the crown. The hypostylid is also appressed to the hypoconid and has a recurved posterointernal angle, which forms an acute ridge bounding the internal face of the crown posteriorly. This incloses with the metastylid a flat open gutter as wide as the metastylid. A sharp ridge marks the internal face of the anterior border, but it is closely appressed to the metaconid, which it does not equal in elevation."

Measurements (after Cope).

Length of crown preserved	37	mm.
Anteroposterior diameter at middle	16.5	"
Transverse diameter at metastylid	8	"
Transverse diameter in front of metastylid	6	"

This species was based on a single lower molar and is known only from this tooth and a series of lower molars (No. 10626, Am. Mus. coll.) from the same locality, which I have referred to the species in the publication above cited. The species therefore is not well characterized. While showing in general a more advanced stage than the species of the upper Miocene, the characters, like those of *E. cumminsii* Cope, are apparently more those of *Protohippus* or *Neohipparion* than of *Equus*. The close appression of the metaconid-metastylid column to the protoconid and hypoconid, and the well rounded outer walls of the protoconid and hypoconid are characters in which it resembles the Miocene species, while the greater backward extension of the metastylid, and the reduction of the anterior-external enamel fold of the protoconid to a mere rudiment are intermediate characters leading toward the true Equus type. If an upper molar seen by the writer, but unfortunately lost in the field, could be identified with this species it would indicate its affinity to the *Neohipparion* or *Hipparion* group rather than to *Protohippus*, for, as I distinctly remember, the crown of this tooth presented a small rounded protocone, well separated from the protoconid.

A careful restudy of this species leads me to conclude that at present it may be regarded as a somewhat intermediate type of rather uncertain reference.

49. **Parahippus crenidens** (*Scott*).

Desmatippus crenidens Scott, Amer. Nat., Vol. XXVII, July, 1893, p. 661.
Parahippus crenidens (Scott) Gidley, Bull. Amer. Mus. Nat. Hist., Vol. XX, 1904, p. 192.

Type: Dentition of both the upper and lower jaws, lacking the incisors, canines, first lower premolar and last upper premolar; the mandible; portions of the radius and ulna, femur, manus and pes, and fragments of other bones.

Type locality: Deep River valley, Montana.

Horizon: Middle Miocene, Deep River formation.

Author's description (*op. cit.*): "*Desmatippus* gen. nov.— Molars and premolars short crowned, the valleys more or less filled with a thin deposit of cement. In the upper series the posterior transverse crest is connected with the outer walls and sends forward a process which extends nearly to the anterior conule. Inner cusps of lower teeth expanded so as to narrow

entrances to the valleys. Median inner cusps (a, a′ of Rütimeyer) much more distinctly separated than in the older genera.

"*D. crenidens* sp. nov.— Posterior transverse crests of upper cheek teeth sinuous; limbs elongate and slender; size moderate.

"This interesting new equine very satisfactorily fills the gap between *Miohippus* and *Protohippus*. The type specimen was found by I. Benet in the upper strata of the Deep River." (For detailed description see Scott, Trans. Amer. Phil. Soc., Vol. XVIII, 1896, p. 84.)

Measurements.

Diameters of	p^1:	anteropost.	15	mm.,	transv.	10	mm.
"	"	p^-:	"	22	"	"	20	"
"	"	p^3:	"	18	"	"	22	"
"	"	p^4:	"	.....18.5	"	"	22	"
"	"	m^1:	"	.....17.5	"	"	.....22.5	"
"	"	m^2:	"	16	"	"	21	"

(For measurements of foot bones see Scott, Trans. Am. Phil. Soc., Vol. XVIII, 1896, p. 89.)

At the time this species was described by Scott and made the type of a new genus, *Desmatippus*, the characters of *Merychippus* were not well understood, and the genera *Parahippus*, *Anchippus*, and *Hypohippus* were not well known, the latter three genera being regarded by Cope and others as representing milk dentitions of species of *Protohippus* or *Hipparion*. As now known, with the exception of *Anchippus* which I regard at present as equivalent to *Parahippus*, these are all well defined and clearly distinct genera. The definition of *Desmatippus* given by Scott exactly fits that of *Parahippus* Leidy as that genus is now understood. And since a comparison of types and the study of other material amply confirm the likeness of characters, I have, in a former publication (*op. cit.*) transferred *D. crenidens* Scott to that genus.

The species agrees very nearly in size with *P. brevidens* (Marsh) but is apparently distinguished from that species by a less marked angulation of the metaloph, and the somewhat shorter proportionate height of the principal cones. Scott considered that *P. crenidens* stands 'morphologically' exactly intermediate between *Miohippus* and *Protohippus*. But a better knowledge of the tooth structure of these earlier forms of horses obtained from far more abundant material does not seem at all to confirm this opinion. While teeth of the *Desmatippus* (*Parahippus*) type represent a much more advanced stage than *Miohippus* or *Mesohippus* as seen in the tendency to a greater height of crown, the complete union of the metaloph with the ectoloph, the development of a more or less well defined spur (crochet) on the anterior wall of the metaloph, and in the lower teeth of a more complete

division of the median inner cusps (mcd. and msd.) they are still, in general structure, essentially Anchitheriinæ-like in character, while they differ widely in some essential features from the *Merychippus* or *Protohippus* form of tooth. The chief points of difference between the two groups, apparently not bridged over by any known form, are these: (1) In the upper cheek teeth of the Anchitherinæ group the inner cones, pr and hy, are larger than the median conules (pl and ml), presenting by far the greater grinding area. (2) The median conules, especially the protoconule, if developed, are more or less conical in outline, not having assumed the crescentic form observed in *Merychippus*. In the Protohippinæ the proportions of the inner cones and median conules are exactly reversed, and the greatly enlarged conules have fully assumed the crescentic form essential to the complete inclosing of the cement lakes, or fossettes, while they form the principal functional part of the inner portion of the crown.

50. **Hypohippus equinus** (*Scott*).

Anchitherium equinum Scott, Amer. Nat., Vol. XXVII, July, 1893, p. 661.

Type: Fragmentary skull and jaws with nearly complete dentition, and parts of the skeleton.

Type locality: Deep River valley, Montana.

Horizon: Middle Miocene, Deep River formation.

Author's description (*op. cit.*): "Size equal to that of *A. aurelianense*, but with teeth relatively larger; lower incisors without enamel pits; humerus with bicipital tubercle and double bicipital groove.

"This is the first American species of Anchitherium in the restricted sense in which that name is here employed. It was found by Mr. Benet in the upper beds." (For detailed description see Scott, Trans. Am. Philos. Soc., Vol. XVIII, 1896, p. 94.)

Measurements.

Diameters of	p^1:	anteropost.	15.5	mm.,	transv.	11	mm.
"	" p^2:	"	25	"	"	25	"
"	" p^3:	"	22.5	"	"	28	"
"	" p^4:	"	23	"	"	30	"
"	" m^1:	"	23	"	"	29.5	"
"	" m^2:	"	21.5	"	"	29	"
"	" m^3:	"	19	"	"	25	"

This species has been well defined but its characters are without question those of *Hypohippus* as that genus is now understood, and it is quite distinct from the European *Anchitherium*, the genus in which it was placed by Scott.

51. **Neohipparion whitneyi** *Gidley.*

Neohipparion whitneyi GIDLEY, Bull. Amer. Mus. Nat. Hist., Vol. XIX, 1903, p. 467.

Type: A complete skeleton of an adult individual (No. 9815, Amer. Mus. coll.). *Paratypes*: Partial skeletons of five associated individuals, some of which are of young animals with milk dentition.

Type locality: Little White River, near the Rosebud Indian Agency, South Dakota.

Horizon: Upper Miocene, Nebraska formation.

Author's description (op. cit.): *Generic characters.*[1] Protocone free except at base, as in *Hipparion.* Protocone comparatively large and usually much expanded anteroposteriorly. Enamel foldings simple as compared with *Hipparion,* but usually more complex than in *Protohippus* or *Pliohippus.* So far as known the facial fossæ are never pocketed, nor are their borders sharply defined. The median external basal column present in the lower milk molars as in *Hipparion,* but shorter and much more expanded anteroposteriorly. Digits, in general, more slender than in *H. gracilis,* and the lateral digits much more reduced.

Specific characters. Size about equal to *Neohipparion occidentale,* but enamel foldings much more simple, even more simple than in *N. affine. N. whitneyi* further differs from *N. affine* in the much stronger development of the styles of the ectoloph. Protocone relatively large and very much elongated in cross-section anteroposteriorly. Inner or lingual, wall of the protocone flat and slightly depressed, as is usual in *Equus caballus.* Metapodials very long and slender. Lateral digits greatly reduced, their terminal phalanges not extending to the distal end of the first phalanx of the median digit. (For more detailed description see Gidley, *op. cit.*)

Measurements (in part).

Diameters of p^1:	anteropost.....	9.5	mm.,	transv.....	7	mm.
" " p^2:	"	29.5	"	"	23.5	"
" " p^3:	"	25	"	"	25	"
" " p^4:	"	25	"	"	25.5	"
" " m^1:	"	22	"	"	23	"
" " m^2:	"	24	"	"	23	"
" " m^3:	"					
Total length of series.....					152	"
Width across external incisors.....					55	"

[1]This definition has been revised and made broader to include more accurately all the species referred to the genus.

Milk dentition (upper).

Diameters of dp^2:	anteropost.	31.5 mm.,	transv.	21.5 mm.
" " dp^3:	"	26	"	"	21	"
" " dp^4:	"	29	"	"	20	"

This species was selected as the type of a new genus (*op. cit.*) closely allied to, but apparently distinct from, the European *Hipparion*. The genus includes practically all the North American species of upper Miocene horses, described by Leidy and Cope under the synonymous names *Hipparion* and *Hippotherium*. The specimen on which the species was founded being so unusually complete and well preserved constitutes a remarkably good type for comparison.

52. **Protohippus simus** *Gidley.*

Protohippus simus Gidley, Bull. Amer. Mus. Nat. Hist., Vol. XXII, 1906, p. 139.

Type: Anterior portion of adult skull with nearly complete dentition (No. 9820, Amer. Mus. coll.). *Paratype*: A portion of upper jaw containing all the large cheek teeth, except m^1, (No. 10871 Amer. Mus. coll.).

Type locality: Little White River, near the Rosebud Indian Agency, South Dakota.

Horizon: Upper Miocene, Nebraska formation.

Author's description (*op. cit.*): "These specimens represent an animal very distinct from species of the *P. mirabilis* and *P. supremus* type, but apparently more closely allied to *P. perditus*, though somewhat larger and differing from that species in the following characters:

"In the upper teeth the protocones show a more progressive stage in their fuller development anteriorly, thus forming a deeper infolding of the enamel between them and the protoconules. In other respects the teeth do not differ greatly from those of *P. perditus* except that the cement lakes are narrower transversely.

"The chief points of difference are in the skull characters. The muzzle is short but much broader than in *P. perditus*. The incisive border is but little curved. This, together with its great breadth, gives the muzzle a rather truncate appearance.

"The palate is broader and less arched than in *P. perditus*, especially forward of the premolars, where it is relatively very flat. The anterior palatine foramina are elliptical in outline and are placed in about the same relative position as in *P. perditus*.

"The malar fossa is wanting, as in *P. perditus*, but the lachrymal fossa is broader, much shallower, and less sharply defined than in that species.

The skull appears to have a comparatively great vertical depth, but this may be due in part to distortion, as it is somewhat compressed laterally.

"*Measurements.*

Type (No. 9820).

Length of dental series m^3 to i^3	200	mm.
" " molar-premolar series m^3 to p^2	135	"
" " molar series	62	"
" " diastema between canine and i^1	15	"
" " muzzle from p^2 to i^1	65	"
Diameters of m^1 (antero-posterior	20	"
(transverse)	23	"
Diameters of p^4 (antero-posterior)	21	"
transverse	24.5	"
Width of palate between fourth premolars	48	"
" " " " first "	41	"
" " " at narrowest point	31.5	"
" " across incisive border	61	"
Depth of skull taken in line with m^1	112	"

53. **Neohipparion dolichops** *Gidley.*

Neohipparion dolichops Gidley, Bull. Mus. Nat. Hist., Vol. XXII, 1906, p. 148.

Type: A portion of the right maxillary containing the molariform cheek teeth from p^2 to m^2, inclusive (No. 10865 Amer. Mus. coll.).

Paratype: Complete lower jaws with full dentition, and an associated upper molar, m^2, (No. 10832 Amer. Mus. coll.).

Type locality: Big Spring Cañon, near head waters of the Little White River, South Dakota.

Horizon: Upper Miocene, Nebraska formation.

Author's description (*op. cit.*): "These specimens represent a species about equal in size to *N. affine* (Leidy). But they differ from that species in (1) the more open fossettes in the upper teeth, (2) the greater complexity of the enamel foldings, and (3) the proportionally smaller and more rounded protocones.

"From *N. occidentale* this species differs in (1) its smaller size and (2) different proportions of the premolars, which are relatively broader transversely.

"Compared with *N. whitneyi* it is distinguished by (1) it smaller size and (2) by the greater number of folds in the enamel walls of the metaloph in the upper teeth, (3) the more open fossettes, and (4) the more rounded forms of the protocones. The small portion of skull preserved in the type does not admit of many comparisons, but a distinctive feature is shown in

the extreme forward position of the infraorbital foramen, which is placed directly above the space between p^2 and p^3. The masseter ridge extends but little farther forward than in *N. whitneyi.*

"The lower jaw is much longer and more slender than in *N. whitneyi,* or any other known Miocene species of horse. The muzzle portion is proportionally longer than the average of a dozen specimens of *Equus caballus* examined.

"The lower border of the ramus is bowed as in *N. whitneyi* and *N. gratum.*

"*Measurements of Type* (*No. 10865*).

Diameters of p^2:	anteropost.	30	mm.,	transv.	22	mm.
" " p^3:	"	23	"	"	23.5	"
" " p^4:	"	23.5	"	"	23+	"
" " m^1:	"	20	"	"	22	"
" " m^2:	"	20	"	"	21.5	"

54. **Neohipparion niobrarense** *Gidley.*

Neohipparion niobrarense Gidley, Bull. Amer. Mus. Nat. Hist., Vol. XXII, 1906, p. 151.

Type: Anterior portion of skull with lower jaws, both containing complete dentition (No. 10828, Amer. Mus. coll.).

Type locality: Near Fort Niobrara, Nebraska.

Horizon: Upper Miocene, Nebraska formation.

Author's description (*op. cit.*): "The type of this species represents an animal but little larger than *N. gratum* and differing from it in the following characters:

"(1) The skull, especially in the nasal and premaxillary region, is longer and narrower; (2) the palate is narrow and more arched; (3) the anterior palatine foramina are more open but do not extend as far backward as in *N. gratum*; the posterior palatal notch apparently extends as far forward as the middle of m^1; (4) the malar fossa is wanting; (5) the lachrymal fossa is larger, extends farther backward, and has a rather sharply defined posterior border. (6) the symphysis of the lower jaw is longer and narrower than in *N. gratum* but is not so extreme in proportions as in *N. dolichops*; and (7) the ramus is bowed as in *N. gratum* but has a less vertical depth.

"*Measurements of Type* (*No. 10828*).

Diameters of p^1:	anteropost.	11	mm.,	transv.	7	mm.
" " p^2:	"	22	"	"	19.5	"
" " p^3:	"	16.8	"	"	21.8	"
" " p^4:	"	17	"	"	21.5	"
" " m^1:	"	16.5	"	"	20.5	"
" " m^2:	"	16.4	"	"	20	"
" " m^3:	"	21	"	"	19	"

Skull.

Total length of molar-premolar series including p^1	117	mm.
Total length of molar-dental series, m^3 to i^1	185	"
Length of diastema between p^1 and i^3	53	"
Width of palate between first molars	38	"
Width of palate between second premolars	27.5	"
Width of palate in front of first premolars	21	"
Width of incisive border	28	"
Height of skull above m^1	86	"
Distance from orbit to anterior narial notch	115	"

Lower Jaw.

Total length of jaw	265	"
Length of complete dental series m_3 to i_1	185	"
Length of molar-premolar series	110	"
Length of diastema between p_2 and i_3	52	"
Width of symphysis at narrowest point	21	"
Width across incisive border	34	"
Depth of jaw at m_1	53	"
Height of condyles above bottom of jaw	140	"

"The type specimen is of a very old individual with the tooth characters practically obliterated by wear. The skull and jaw characters, therefore, form the basis of its generic reference.

"In a lot of upper teeth in the United States National Museum, referred by Leidy to his "*Hipparion speciosum*," there are several specimens which agree in size with the teeth of *N. niobrarensis*. These specimens are clearly of the Neohipparion pattern and are possibly referable to this species."

Merychippus campestris sp. nov.

Type: Upper molar — premolar series of the left side associated with the lower jaws fragments of skull, vertebræ, and portion of fore and hind limbs and feet. (No. 9069, Amer. Mus. coll.)

Type locality: Pawnee Buttes, Colorado.

Horizon: Middle Miocene, Pawnee Creek formation.

Species character: In the American Museum collection of fossils from Pawnee Buttes, Colorado, there is a specimen, consisting of upper teeth

associated with the lower jaws, fragments of skull, vertebræ, and portions of the fore and hind limbs and feet, apparently all of one individual. This specimen represents an undescribed species of horse representing apparently a Pliohippus phase of the Merychippus group. The milk dentition is not known, but the tooth crowns are apparently as short as in many of the species in which the milk teeth are known to be of the brachyodont type, and the specimen comes from a lower horizon than any known species of *Pliohippus*, with the possible exception of *Pliohippus spectans* (Cope) from Cottonwood Creek, Oregon. The characters presented are more primitive throughout than those of other described species of *Pliohippus*.

The upper molars though somewhat smaller have much the same general appearance as *Pliohippus spectans*, but differ from that species in the following particulars: (1) The molars are shorter crowned; (2) the external cones (*pa* and *ma*) are thicker transversely, making a less transverse width for the fossettes; and (3) the protocones are smaller and more rounded, being nearly circular in outline as in the South American *Hippidion*. Like *P. spectans*, the horns of the fossettes end in broadly open loups and their enamel borders are very simple throughout.

The lower jaws are comparatively long and slender; the symphysis is shallow but heavy. There is a considerable diastema between the canine and the first incisor. The lower borders of the rami are considerably bowed, but the jaws have the appearance of having been deformed by some disease of the bone in life which affected especially the region of the ramus containing the molariform teeth, hence there is some doubt as to this being the normal form.

There are apparently no special characters shown in the portions of skull preserved, except that the space between the postglenoid process and the mastoid process is somewhat greater than in horses of the *Neohipparion whitneyi* type, the postglenoid process is more robust, and the mastoid bone extends outward and overlaps the exoccipital to a greater degree. In these characters it more nearly resembles *Equus caballus*.

The atlas is more progressive in general character than that of *N. whitneyi* of the Upper Miocene or any species of horses from the middle Miocene in which the atlas is known. The transverse processes are well expanded and the anterior external notch is partially inclosed, suggesting a strong tendency to the condition of an inclosed foramen which has been attained by *Equus* and *Hippidion*.

Metacarpal III is moderately short and heavy (see measurements) and the lateral metacarpals, mII and mIV, are very much reduced. The shaft of the ulna is much reduced and fused with the radius for the greater part of its length.

Measurements.

Diameters p^1:	anteropost.	.13	mm.,	transv.	7.5	mm.
" p^2:	"	.29	"	"	22	"
" p^3:	"	.23	"	"	25	"
" p^4:	"	.23	"	"	25.5	"
" m^1:	"	.20.5	"	"	24	"
" m^2:	"	.21.5	"	"	25	"
" m^3:	"	.21.5	"	"	21.5	"
Total length of molar premolar series					144.5	"
Total width of occiput of skull					80	"
" " " " "					55.5	"
Width of condyles					300	"
Length of jaw forward of premolars					87	"
Diastema between premolar 2 and canine					35	"
Depth of symphysis					30	"
Width of symphysis at narrowest point					31	"
Depth of ramus at p_4					44	"
" " angle immediately behind m_3					78	"
Length of radius					225	"
Width of radius at distal end					44	"
Length of metacarpal III					175	"
Transverse diameter, proximal end					28.5	"
Anteroposterior diameter, proximal end					24	"
Transverse diameter at middle of shaft					21	"
" " " distal end shaft					25	"
Length of femur					244	"
" " tibia, exclusive of spine					275	"
Transverse width of tibia, proximal end					60	"

58. **Hypohippus osborni** sp. nov.

Type: A nearly complete skeleton (No. 9407, Amer. Mus. coll.). Found by Barnum Brown, Amer. Mus. Expedition of 1901.

Paratype: A palate with complete dentition, associated with lower jaws and other parts of the skeleton (No. 9395, Amer. Mus. coll.).

Type locality: Pawnee Buttes, northeastern Colorado.

Horizon: Middle Miocene, Pawnee Creek beds.

Species characters: As indicated by the teeth, this species is intermediate in size and progressive development between *H. affinis*, the type of the genus, and *H. equinus* (Scott), the latter being the smallest and least specialized. Compared with *H. equinus* the principal differences are, (1) cheek teeth relatively longer crowned; (2) outer walls of upper cheek teeth more deeply curved; (3) protocone and hypocone more compressed anteroposteriorly; and (4) the incisors are relatively wider.

It does not seem necessary here to describe in detail the different ele-

ments of the type skeleton since, except for their somewhat larger size, they so nearly resemble those of the *H. equinus* specimen so fully described and compared by Scott.[1] However, a few skull characters and points of skeleton proportions, not so clearly shown in the less complete type of *H. equinus*, seem of sufficient importance to merit note.

In general the skull and teeth have retained many of the more primitive characters seen in *Mesohippus* while the lines of specialization have been, as pointed out by Scott, away from rather than toward the line of descent leading to the modern forms of horses. Thus the median conules (ml and pl) have diminished in size while the tooth crown has but slightly or not at all increased in height. The skull and jaws also have become somewhat more elongate but have decreased rather than increased in vertical depth. Other characters of the skull worthy of note are presented in the great enlargement of the lachrymal fossa which forms a deep pocket in the side of the face, and in the broad expansion of the nasals, especially in their anterior portion.

The unusually complete skeleton on which the genus *Neohipparion* (*N. whitneyi*) was found affords an opportunity for an interesting comparison of two wholly different types of horses.

In general proportions *H. osborni* is longer necked, longer bodied and shorter limbed than *N. whitneyi*. The relatively smaller head with its brachyodont uncemented teeth, its less vertical depth, its more anteriorly placed orbits which are not inclosed behind, presents a totally different appearance from that of *N. whitneyi* which is very much nearer the typical modern horse. A comparison of the feet also shows some marked differences. In *H. osborni* the lateral toes are relatively no more reduced than in *Mesohippus* and are functional, this together with the long, flattened, terminal phalanx of the median digit presents to the ground a comparatively large foot area. In *N. whitneyi* the toes are long and slender, the lateral ones being so greatly reduced as to render the foot practically monodactyl.

Measurements of Teeth.

Diameters of	p^1,	anteropost.	18	mm.,	transv.	11.5	mm.	
"	" p^2,	"	27.3	"	"	26.	"	
"	" p^3,	"	25.7	"	"	28.7	"	
"	" p^4,	"	27.	"	"	29.9	"	
"	" m^1,	"	27.2	"	"	31.	"	
"	" m^2,	"	23.3	"	"	31.5	"	
"	" m^3,	"	21.	"	"	27.8	"	
Total length of series (p^1 to m^3)							151	mm.
" " " molar series (m^1 to m^3)							69	
Width of incisive border across external incisors,							44	

[1] Trans. Amer. Phil. Soc., Vol. XVIII, 1896, pp. 94–122.

Skull Measurements.

Total length of skull, incisors to condyles	371.
" " " palate	164.
Width of palate between first molars	54.
Length of diastema between upper canine and i^3	10.
" " " " " " " p^1	28.
Width of skull across zygoma	160.3
" " condyles	60.4

59. **Parahippus pawniensis** sp. nov.

Type: The upper and lower cheek teeth of one side, and fragments of the skeleton, including parts of the feet. (No. 9085, Amer. Mus. coll.).

Found by Handel T. Martin, Amer. Mus. Expedition of 1898.

Type locality: Pawnee Buttes Creek, northeastern Colorado.

Horizon: Middle Miocene, Pawnee Creek beds.

Species characters: (1) Cheek teeth shorter crowned than in any other species hitherto described; (2) The metaloph in the upper teeth is comparatively straight, with enamel walls simple except for the median anterior fold, or crotchet; (3) crotchet slightly united with the protoconule at its base; (4) external walls of paracone and metacone relatively flat, as in *P. crenidens*, with only a faint indication of the median rib; (5) crowns of upper cheek teeth proportionately narrower than in *P. crenidens*; (6) the metastylid in the lower teeth less prominent and less distinctly separated from the metaconid than in the other known species of this genus.

This type apparently represents one of the least specialized species of the genus.

Measurements.

Diameters of p^1, anteropost.		mm., transv.		19.	mm.
" " p^3, "	17.9	" "		19.8	"
" " p^4, "	17.2	" "		20.1	"
" " m^1, "	17.8	" "		20.	"
" " m^2, "	16.5	" "		18.7	"
" " m^3, "	15.	" "		17.	"
Total length of series p^2–m^3 (approximate)				92.	mm.
Total length of molar series (m^1–m^3)				46.2	"

60. *Parapippus coloradensis* sp. nov.

Type: A single upper molar, m^3 (No. 9040, Amer. Mus. coll.).

Paratypes: two fragments of lower jaws containing teeth (Nos. 9412 and 8282, Amer. Mus. coll.).

Type locality: Pawnee Creek, northeastern Colorado.

Horizon: Middle Miocene, Pawnee Creek beds.

Species characters: (1) Larger than *P. pawniensis*, about equaling *P. crenidens* in size; (2) tooth crown comparatively high; (3) outer walls of the paracone and metacone strongly ribbed, (4) metaloph with crotchet well developed, the type tooth presenting two additional enamel folds; (5) the metastylid of the lower teeth well developed and separated from the metaconid by a well marked groove reaching nearly to the base of the crown. (6) On the external walls of the lower teeth the enamel is very rough, almost wrinkled in appearance.

The characters presented in these teeth indicate a species of *Parahippus* somewhat more advanced in development than *P. crenidens*, and decidedly more specialized than *P. pawniensis*.

Measurements.

Diameters of m^3 (type), anteropost.	16	mm., transv.	20.5	mm.
" " p_4 (No. 9412) "	21.5	" "	17.5	"
" " m_2 " "	20.	" "	15.5	"
Height of crown of m^3,			14.5	mm.
" " " " p^4,			15.5	"
Total length of lower series, less p_1,			128.	"

Summary and Conclusions.

In the foregoing revision the lines of comparison and study have been confined principally to characters of the teeth and skull, for the reason that by far the greater number of species of horses have been founded on tooth and skull material not associated with other parts of the skeleton. The expeditions of the last few years however are constantly increasing the collections and adding quantities of more complete material, including many specimens in which teeth and bones of the feet are associated. This class of material will greatly aid in working out more fully than has been done the characters of foot development of horses, and should result in throwing added light on the phyletic relations of the extremely varied groups which seem to have reached their culmination, as regards numbers of genera and species, in the Miocene period.

The principal results attained by this study are, first, a better understanding and interpretation of the principal characters shown in the numerous and varied types representing the American Miocene Horses; second, the reëstablishment and better definition of several of the genera and species proposed by Leidy, the validity of which was questioned by Cope; and third, a reclassification of the entire family of the Equidæ.

As at present understood, the fact seems to be fairly well established that there is a considerable phyletic hiatus between the groups of the Equidæ

as above subdivided, which are as yet not bridged over by intermediate forms. Such a hiatus seems especially marked between the Anchitheriinæ and the Protohippinæ, while these groups greatly overlap each other in time. So far as indicated by any known species the Anchitheriinæ could not well have stood in direct ancestral line to the latter group or to the Equiinæ. There seems also to be almost as decided a gap between the Anchitheriinæ and the known species of the older group, the Hyracotheriinæ. The Equiinæ may well have been derived from some species of the *Protohippus* division of the Protohippinæ.

59.57.86C

Article XXXVI.— NEW FORMS OF CATOCALA.

By William Beutenmüller.

The following paper contains a few notes on imperfectly known species and descriptions of some apparently new forms of *Catocala* that for some years have remained unnamed in the Museum and other collections.

Catocala nevadensis sp. nov.

Male and Female.— Head and thorax black mixed with white. Fore wings black, finely powdered with white and blue, and shaded with white. Transverse anterior line broadly geminate, black, filled with white or gray; two subcostal teeth, thence with two strong outwardly oblique, curves or zigzags. Transverse posterior line black, distinct, very strongly dentate, the two teeth opposite the cell subequal and very sharply pointed, thence with smaller, subequal, sharp teeth to the lower inflection which is short and usually filled with black. Subterminal line very broad, almost upright, white, and strongly dentate. Space between the posterior and subterminal lines creamy white dusted with black. Reniform almost obscured by a black shade; when evident it is whitish with a black lunule. It is preceded and followed by a white shade costally. Subreniform white, powdered with black and connected with the posterior line, closed or slightly open. Terminal space dusted with white with a row of small black spots on the margin. Fringes gray or whitish. Hind wings brick red. Median black band broad, and terminating abruptly some distance before the inner margin. Marginal black band not very broad. Fringes white. *Under side*: Fore wings black with a discal, white half-band and a broad white band beyond the middle. This band is distinctly dentate above the inner margin. Hind wings dull brick red. Median band more irregular. Marginal band similar to the above. Expanse, 70–78 mm.

Habitat.— Lake Tahoe, Sierra Nevada, California, August.

Types.— Three males and five females, American Museum Natural History.

This species was received by the late Hy. Edwards some years ago from Mr. McGlashan who bred it from larvæ found on willow in July. It is a very striking species and may be known at once by the black fore wings with white shades and the very prominent dentate, transverse posterior and subterminal lines. The median band of the hind wings is very similar to that of *C. groteana*.

Catocala nevadensis var. **montana** var. nov.

Male and Female.— Head and thorax bluish white mixed with black. Fore wings almost uniform bluish gray and evenly powdered with black atoms making

the creamy white shade and subterminal line less conspicuous than in the type form. Reniform large, black-ringed, in a blackish and bluish shade. Subreniform white dusted with black. Transverse anterior and posterior lines as in the type but less prominently colored. Hind wings the same as in the type. Expanse, 70–78 mm.

Habitat.— Lake Tahoe, Sierra Nevada, California; Sissons, Shasta Co., California; New Westminster, B. C.

Types:— Four males and six females, American Museum of Natural History.

This is apparently a pale form of *C. nevadensis.* It may be known by the broad, pale blue gray fore wings, which are finely powdered with black. It very much resembles *C. pura* but it is a heavier bodied and broader winged insect. It is possible that *C. nevadensis* and its variety may ultimately prove to be nothing more than forms of *C. pura* but in the present status of the case, I am unable to decide.

Catocala groteana *Bailey.*

Catocala groteana Bailey, N. Amer. Entomol., Vol. I, 1879, p. 21; Snow, Trans. Kans. Acad. Sci., Vol. VIII, 1883, p. 38; French, Can. Ent., Vol. XXXIII, 1901, pp. 12, 206; Holland, Moth Book, 1903, p. 264, pl. xxxii, fig. 4.

Catocala briseis var. *groteana* Hulst, Bull. Bk. Ent. Soc., Vol. III, 1880, p. 10; *ibid.*, Vol. VII, 1884, p. 46; Snow, Trans. Kans. Acad. Sci., Vol. VII, 1881, p. 63; Smith, Bull. 44, U. S. Nat. Mus., 1893, p. 342; Dyar, Proc. U. S. Nat. Mus., Vol. XXVII, p. 878.

This is a much larger and broader winged species than *C. briseis,* of which it was considered to be a variety by certain writers. I consider it to be a valid species.

Catocala briseis var. **albida** var. nov.

Female.— Head and thorax whitish gray. Fore wings bluish gray, whitish on the costa before and beyond the reniform. Transverse lines distinct, black. Reniform black with a whitish and black annulus. Subreniform whitish, black-ringed. Subterminal line bluish white. Hind wings as in *C. briseis.*

Habitat.— Manitoba, Canada.

Type.— One female. Collection of George J. Keller.

This strange form of *Catocala briseis* may be known at a glance by the bluish gray fore wings and the contrasting, black transverse lines.

Catocala unijuga var. **agatha** var. nov.

Female.— Head and thorax dark brownish black, sparsely mixed with white. Fore wing uniform dark brownish black with whitish atoms. Transverse lines and

spots obscured by the ground color of the wings. Subterminal line white and distinct. Hind wings the same as in *C. unijuga*. Expanse, 84 mm.

Habitat.— Wisconsin.

Type.— One female. Collection United States National Museum.

Catocala unijuga var. **semirelicta** *Grote.*

A colored figure of the type of *Catocala semirelicta* was kindly sent to me by Sir George F. Hampson with the statement that "it is certainly not *C. briseis*, but may be a variety of *C. unijuga*." It is nearly like the form described by C. E. Worthington as *Catocala lucilla* (Papilio, Vol. III, 1883, p. 39), which is considered to be a variety of *C. unijuga*. The type of *C. semirelicta* is very much faded and very unlike the figure published by Grote (Proc. Buff. Soc. Nat. Sci., Vol. II, 1875, pl. i, fig. 11).

Catocala diantha sp. nov.

Male and Female.— Head and thorax dark grayish brown. Fore wings pinkish brown or pinkish gray, finely dusted with black scales. Transverse anterior line broadly geminate, blackish or brown, with three distinct waves or broad dentations, the upper one sometimes in form of two subcostal teeth. Transverse posterior line distinctly dentate, the two teeth opposite the cell, broad, not long, and subequal, thence with a small tooth, followed by two large teeth, which take in the subreniform; lower inflection broadly open outwardly. Subterminal line grayish or pinkish, preceded by a more or less distinct brown shade. Terminal row of spots black. Reniform subobliterate, and in a brownish or blackish cloud, with two black rings. Subreniform large, pale with brown scales, connected with the posterior line and usually open. Hind wings bright red. Median black band curved. very slightly constricted and terminating some distance before the inner margin, Marginal black band not very broad, with a very narrow creamy white apical patch which is sometimes wanting. Fringes white or somewhat cut with brown. *Under side*: Fore wings black, with a white discal half band and curved, broad, white band beyond the middle. Apex ashen white. Hind wings dull red, whitish beyond the median band, from the costa to the middle. Median band more irregular. Marginal band sometimes narrowly edged with creamy yellow terminally. Fringes wholly white. Expanse 60 to 68 mm.

Habitat.— Glenwood Springs, Colorado, July–Sept., and Huachuca Mts., Arizona (William Barnes); New Mexico (F. H. Snow); Colorado and Arizona (Jacob Doll); Denver, Colorado (E. J. Oslar); Las Vegas, New Mexico (Schwarz and Barber).

Types.— Collections, William Barnes, Jacob Doll, American Entomological Society, American Museum of Natural History, and United States National Museum.

A fine series of this singular species is before me and I am unable to associate it with any of the known species of *Catocala*. It belongs in the *faustina* group and it is possible that it may ultimately prove to be a form of *C. verecunda*. It may be recognized by the pinkish brown fore wings.

Catocala euphemia sp. nov.

Head and thorax dark gray brown, somewhat subolivaceous with glaucous hairs. Fore wings almost uniformly colored, gray brown with a subolivaceous tint. Basal half-line black, with a large tooth. Transverse anterior line black, much dilated on the costa, with three large outward curves, and preceded by a subolivaceous shade. Basal dash black, sometimes absent. Transverse posterior line black heavily marked on the two large teeth. The two teeth opposite the cell, strongly produced and very acute, thence with two small teeth and a large blunt one; lower inflection long and broad. Reniform subolivaceous with two black rings. Subreniform large, concolorous with the ground color, black-ringed and connected with the posterior line, where it is broadly open. Space beyond the posterior line subolivaceous with the subterminal line grayish and strongly dentate. Hind wings dull orange yellow. Median black band strongly constricted at the middle and narrowly terminating at the inner margin. Marginal band black, edged with yellow, apical patch yellow. Fringes yellow, slightly cut with brown. *Under side*: Fore wings largely pale orange yellow, an oblique, black discal shade band, and a broad black transverse band beyond the middle which is strongly angulated above the inner margin; terminal band black dusted with orange. Hind wings orange yellow. Median band narrow and very strongly constricted. Marginal band narrow, orange terminally and at the costa. Fringes uniform orange yellow. Expanse 80 to 85 mm.

Habitat.— Huachuca Mts., Arizona; Texas.

Types.— American Entomological Society, American Museum of Natural History, and Brooklyn Institute of Art and Science.

Allied to *C. subnata* and *C. neogama* and it appears to be an intermediate species. It may be known by the uniform, evenly colored dark gray brown fore wings with a somewhat subolivaceous tint. The transverse anterior line is curved differently and is less oblique than in *C. subnata*, making the basal space smaller. The transverse posterior line and spots are similar to those of *C. subnata*. It was described from four males and one female. Specimens are also in the collections of Mr. O. C. Poling and Dr. William Barnes.

Catocala volumnia *Hy. Edwards.*

I consider *C. volumnia* to be a valid species and not a variety of *C. irene*, as it was placed by the late Hy. Edwards and other writers. Mr. O. C. Poling sent me a fine specimen from Los Angeles, California, in which the hind wings are bright carmine and the fore wings more brilliantly colored than the type. A specimen was also received from Cartwright, Canada, by Dr. James Fletcher, which is very similar to the one in Mr. Poling's collection.

Catocala faustina var. **lydia** var. nov.

Male and Female.— Fore wings heavily overlaid with blackish scales so as to almost obscure the ground color and markings. Subterminal line and space between the geminate transverse anterior line bluish white. Hind wings the same as in *C. faustina.*

Habitat.— Provo City, Utah; Lake Tahoe, Sierra Nevada, California; Montana; New Mexico.

Types.— Collections, American Museum of Natural History, United States National Museum, Jacob Doll, and George J. Keller.

An extreme form of *C. faustina,* bearing the same relationship to this species as the variety *somnus* does to *C. luciana.* A fine series of *C. faustina* is in the collection of Mr. George J. Keller showing intergradations between the type form and the variety. Mr. Jacob Doll bred this form from Willow in New Mexico.

Catocala cærulea sp. nov.

Male.— Head and thorax blue gray mixed with black. Fore wings blue or bluish gray mixed with fine black atoms. Transverse anterior line black, geminate, with three prominent dentations. Transverse posterior line black with the two teeth opposite the cell moderate, subequal, lower part of line with a strong inward bend. Beyond this line is a brown shade. Subterminal line black, dentate, and filled with blue gray. Reniform brown mixed with blue, margined with black and containing a black lunule. Subreniform sordid white and connected with the posterior line. Hind wings red with the black median band broad and not reaching the inner margin. Marginal black band broad, excavate before the hind angle. Fringes bluish. Expanse, 55 to 60 mm.

Habitat.— Oregon.

Allied to *C. faustina* and *C. allusa.* It may be known by the bluish fore wings.

Catocala ophelia *Hy. Edwards.*

This species was made a synonym of *Catocala verrilliana.* I, however, consider it to be a valid species. The fore wings are broader than *verrilliana* and lack the black shades. The transverse anterior line is rather strongly curved in *ophelia* and not even as in *verrilliana.* The outward bend of the transverse posterior line on the inner margin is longer and the hind wings are deeper red with the marginal band much broader than in *verrilliana.*

Catocala ophelia var. **dollii** var. nov.

Male.— Head and thorax dark gray and considerably darker than in *C. ophelia.* Fore wings heavily overlaid with black scales, making the lines and spots less distinct than in *C. ophelia.* Subreniform pale, scaled with brown. Transverse lines the same as *C. ophelia.*

Habitat.— Colorado.

A single specimen of this odd variety is in the collection of Mr. Jacob Doll.

Catocala ultronia var. **lucinda** var. nov.

Male and Female.— Head and thorax brown. Fore wings pale ash or greenish gray; a broad longitudinal, rich brown shade covers the lower third of the wings to the inner margin. This dark shade runs from the base below the basal dash to the transverse anterior line or it extends to the subterminal line. The subterminal line is very vague or wanting. Otherwise the same as *C. ultronia.*

Habitat.— Same as *C. ultronia.*

Described from five males and four females. This variety is generally labeled *C. ultronia* in collections. It may be easily recognized by the ashen gray or greenish gray fore wings with the lower part along the inner margin deep brown.

Catocala miranda *Hy. Edwards.*

Catocala miranda Hy. Edwards, Pap., Vol. I, 1881, p. 118; Beutenmüller, Bull. Am. Mus. Nat. Hist., Vol. IV, 1892, p. 192.

Catabapta judith var. *miranda* Hulst, Bull. Bk. Ent. Soc., Vol. VII, 1884, p. 52.

Catocala judith var. *miranda* Smith, Bull. 44, U. S. Nat. Mus., 1893, p. 351; Packard, Fifth Rep. U. S. Ent. Com., 1890, p. 303; French, Can. Ent., Vol. XXXII, 1900, p. 191.

Very closely allied to *C. judith,* but it is smaller with the lower inflection of the transverse posterior line longer and the outward bend to the inner margin very oblique. In *C. judith* this bend is slightly oblique. The fringes of the hind wings in *miranda* are white and not brown as in *judith.* The under sides of all the wings in *miranda* are wholly smoky brown with traces of a darker transverse bend on each wing. In *judith* the under side of the fore wings are white at the base, with a white discal patch and narrow whitish transverse band beyond the middle. The hind wings are clear white from the base to the broad, black median band, beyond which it is very narrowly whitish. Marginal black band very broad. The types of *C. miranda* and *C. judith* are in the collection of the American Museum.

C. miranda was made a variety of *C. judith* by the late George D. Hulst and in which he is followed by subsequent writers. The type of *C. miranda* is a single male from Washington, D. C. Two examples agreeing with the type are also in the collection of the American Entomological Society.

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